

BULLETIN
OF
ENTOMOLOGICAL RESEARCH.

ISSUED BY THE IMPERIAL
BUREAU OF ENTOMOLOGY.

EDITOR: THE DIRECTOR.

VOL. XIV.

LONDON:
THE IMPERIAL BUREAU OF ENTOMOLOGY,
41, QUEEN'S GATE, S.W. 7.
1923-24.

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(K1785) Wt P 24/D 17 1,000 8/24 H & S Gp 52

CONTENTS.

ORIGINAL ARTICLES.

	PAGE
AUSTEN, MAJOR E. E. Additional Records of Palestine Tabanidae, with Descriptions of New Species	421
BAGNALL, R. S. On a new injurious Thrips affecting Tea in India	455
BOX, H. E. The Bionomics of the White Coffee-leaf Miner, <i>Leucoptera coffeella</i> , Guér., in Kenya Colony (Lepidoptera, Lyonetiidae)	133
BRUG, S. L. Notes on Dutch East Indian Mosquitos	433
BUXTON, DR. P. A. <i>Anopheles</i> Larvae from Palestine and Elsewhere	75
Applied Entomology of Palestine, being a Report to the Palestine Government	289
CHAMBERLIN, J. C. A Systematic Monograph of the Tachardiinae or Lac Insects (Coccidae)	147
CHINA, W. E. A Preliminary Revision of the Oriental Species of <i>Leptocoris</i> , Latr. (Hemiptera, Coreidae)	235
CURSON, H. H. Notes on <i>Glossina pallidipes</i> in Zululand	445
EDWARDS, F. W. Mosquito Notes—IV	1
A Synopsis of the Adult Mosquitos of the Australasian Region	351
FERGUSON, E. W. Notes on the Nomenclature of Australian Tabanidae: Sub-family Pangoniinae	251
GREEN, E. E. Observations on the Coccidae of the Madeira Islands	87
GREEN, E. E., & LAING, F. Descriptions of some new Species and some new Records of Coccidae.— I. Diaspidinae	123
Descriptions of some apparently new Non-Diaspidine Coccidae	415
HARGREAVES, E. Entomological Notes from Taranto (Italy) with References to Faenza, during 1917 and 1918	213
HILL, G. F. A new Australian <i>Phlebotomus</i> (Dipt., Psychodidae)	83
INGRAM, A., & MACFIE, J. W. S. Notes on some African Ceratopogoninae	41
KLIGLER, I. J. Notes on the Hibernation of <i>Anopheles</i> Mosquitos in Palestine	403
LAING, F. A new Psyllid injurious to Fig Trees	247
LLOYD, LL., & JOHNSON, W. B. The Trypanosome Infections of Tsetse-flies in Northern Nigeria, and a new Method of Estimation	265

MACFIE, DR. J. W. S.	
Report of the Distribution of Tsetse-flies in the Neighbourhood of Accra	25
MACGREGOR, M. E.	
<i>Aedes (Stegomyia) mascarensis</i> , MacGregor: a new Mosquito from Mauritius	409
A Note on the Fertilisation of <i>Anopheles</i>	413
MAULIK, S.	
A new Hispid Beetle injurious to Oil Palms in Brazil	245
MILES, H. W.	
On the Life-history of <i>Boriomyia (Hemerobius) nervosa</i> , Fab. (Planipennia, Hemerobiidae)	249
MUIR, F.	
On a new Cixiid attacking Coconut Palms	456
PLOTNIKOV, V. I.	
Some Observations on the Variability of <i>Locusta migratoria</i> , L., in Breeding Experiments	241
SPEYER, E. R.	
Notes upon the Habits of Ceylonese Ambrosia-beetles	11
SWYNNERTON, C. F. M.	
Tsetse-flies breeding in open Ground	119
TATTERSFIELD, F., & MORRIS, H. M.	
An Apparatus for testing the Toxic Values of Contact Insecticides under Controlled Conditions	223
THEODOR, O.	
Pupae of some Palestinian Culicines	341
TONNOIR, A. L.	
A new Biting Ceratopogonid from New Zealand	443
UVAROV, B. P.	
Notes on Locusts of Economic Importance, with some new Data on the Periodicity of Locust Invasion	31
WATERSTON, DR. J.	
Two new Anoplura	99
Notes on Parasitic Hymenoptera	103

MISCELLANEOUS.

Collections Received	121, 221, 347, 457
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ERRATA.

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- Page 104, line 46, for "Grahan" read "Gahan"
 „ 170, line 4, for "J. H. Burkill" read "I. H. Burkill"
 „ 206, line 8, for "karoo" read "karroo"
 „ 255, line 8, for "nor" read "not"
 „ 293, line 2, for "lighter" read "heavier"
 „ 298, line 29, for "23 miles" read "2 to 3 miles"
 „ 313, line 9, for "1·2 per cent." read "1 or 2 per cent."
 „ 367, line 38, for "(Priestly)" read "(Priestley)"
 „ 425, line 6, for "*Haemotopota*" read "*Haematopota*"

IMPERIAL BUREAU OF ENTOMOLOGY.

BULLETIN

OF

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VOL. XIV.

1923.

MOSQUITO NOTES.—IV.

By F. W. EDWARDS.

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CONTENTS :

	PAGE
1. New and little-known Culicine Mosquitos from the Malay Peninsula ..	1
2. Two new Indian <i>Aedes</i>	4
3. Culicine Mosquitos from New Britain	5
4. A new <i>Hodgesia</i> from New Guinea	8
5. A new <i>Rachionotomyia</i> from Tasmania	8
6. A new <i>Taeniorhynchus</i> from Palestine	9

—NEW AND LITTLE-KNOWN CULICINE MOSQUITOS FROM THE MALAY PENINSULA.

The interesting collection of Culicine mosquitos on which these notes are based was made during 1922 by Dr. H. P. Hacker, of the Malaria Bureau, Kuala Lumpur, Federated Malay States. Most of the material was obtained during an expedition to Cameron's Highlands, on the main range near Tapah, in September. A small amount of additional material from Ulu Gombak also yielded some specimens of interest.

The specimens reared by Dr. Hacker from pitcher-plants add one species to this local fauna. The species of mosquitos so far found breeding in pitcher-plants in the Oriental region are the following :—

Megarhinus splendens, Wied., Singapore (*Finlayson*); recorded by Leicester (1908) in note under *Teromyia quasiferox*. The specimens are in the British Museum.

M. ater (Daniels). Pahang River (*Daniels*, 1908).

M. acaudatus (Leic.). Singapore (*Finlayson*); recorded by Leicester.

M. metallicus (Leic.) var. Cameron's Highlands (*Hacker*).

Uranotaenia nivipleura, Leic. Singapore (*Finlayson*); recorded by Leicester.

U. ascidiicola, de Meij. Tjibodas, Java (*Jensen*); recorded by de Meijere (1910).

- U. brevisrostris*, Edw. Kuching, Sarawak (*J. Hewitt*). Specimens in British Museum.
- Rachionotomyia mendacis* (Daniels). Pahang River (*Daniels*, 1908).
- R. vicina*, Edw. The Gap, Selangor (*C. Strickland*, 1915); specimens in British Museum. Cameron's Highlands (*Hacker*).
- R. aranoides* (Theo.). Pahang River (*Daniels*, 1908, as *Skeiromyia fusca*).
- Tijibodas, Java (*Jensen*); recorded by de Meijere as *Ficalbia tenex*. Seramban and Cameron's Highlands (*Hacker*).
- R. dofleini* (Günther) (? = *affinis*, Edw.). Ceylon.
- R. nepenthis*, Edw. Borneo (*Hewitt*); recorded by Edwards (1914).
- Wyeomyia nepenthicola*, Banks (*mus*, Dyar). Philippine Islands.
- Armigeres treubi* (de Meij.). Tijibodas, Java (*Jensen*); recorded by de Meijere.
- Culex (Lophoceratomyia) jenseni* (de Meij.). Tijibodas, Java (*Jensen*); Seramban (*Hacker*).
- C. (L.) hewitti*, Edw. Kuching, Sarawak (*J. Hewitt*); specimens in British Museum.

***Megarhinus metallicus* (Leic.).**

This was described by Leicester from specimens bred from bamboos. Dr. Hacker obtained examples at Ulu Gombak and Cameron's Highlands from living bored bamboos, from dead bamboos, and also one typical female from a tree-hole. He also reared the species from living and dead pitcher-plants on Cameron's Highlands. These last specimens have the prothoracic lobes almost entirely covered with purplish scales, the white ones being very much reduced in number; the first two segments of the male palpi are largely purple instead of golden-scaled above, and the male also differs somewhat from the type as regards the form of the ninth tergite, but these differences are probably individual and not definitely specific or varietal. *M. metallicus* is evidently less restricted in its breeding habits than are some members of the genus, though doubtless more so than *M. splendens*.

In the bamboos *M. magnificus* (Leic.) was found associated with *M. metallicus*.

***Uranotaenia maxima*, Theo.**

This was described by Leicester from two captured females, and no other examples of the species have been reported. Dr. Hacker reared a small series, both sexes being represented, in Cameron's Highlands, from rock pools at the edge of a stream. The males show no special modifications in the legs, but differ from the females in having much more numerous whitish scales on the radius; these scales, instead of being confined to the extreme base of the vein (as in the female), extend for fully half the length of the basal cell. A precisely similar sexual difference occurs in the closely related *U. macfarlandi*, Edw.

***Topomyia spathulirostris*, sp. n.**

Head clothed with rather light brownish scales with a pearly lustre; a narrow silvery area on the vertex adjoining the eyes, and a rather large silvery patch low down on each side. Vertical bristles yellow, orbitals black. Palpi very short, black. Proboscis about as long as the abdomen and considerably shorter than the long front femora. Upper surface black-scaled; in the ♂ a narrow snow-white ring at the base, ventral surface whitish on the basal four-fifths; in the ♀ the basal white ring is absent, but the ventral pale line is indicated. In both sexes the apical fifth, or rather more, of the proboscis (but not the small labella) is very broad and flat. Antennae normal, alike in the two sexes. *Thorax* with blackish integument, rather rubbed in both specimens, but apparently showing the following scale characters: Prothoracic lobes with flat silvery scales; pro-epimera with flat golden scales. Mesonotal scales mostly narrow, curved, dark brownish; a double median row of roundish scales, which on the front margin of the mesonotum are white, but behind this are dark

brown; this double row apparently stopping short in front of the scutellum. Scutellar scales mostly dark brown, a double row of silvery ones in the middle of the median lobe. One pro-epimeral bristle; apparently only two spiracular. *Abdomen* with the tergites uniformly blackish, sternites uniformly golden-scaled. Hypopygium: ninth tergite with the lateral angles drawn out into long points, each bearing a single terminal spine. Side-pieces with small ill-defined hair-tufts at the inner apical angles; large sub-basal lobes each bearing one stout spine which reaches beyond the tip of the side-piece. Claspers split almost to the base into two slender and divergent parts, the outer nearly twice as long as the inner and bearing a long and extremely fine hair at its tip. Aedeagus constructed somewhat as in *T. gracilis*, Leic. *Legs* uniformly dark above, indistinctly paler beneath, more noticeably so in the ♂. Hind femora markedly shorter than the others, the mid pair the longest. *Wings* with dark brown scales, the outstanding ones linear. Upper fork-cell about twice as long as its stem; *An* ending a moderate distance beyond fork of *Cu*. Wing-length, 3 mm.

MALAY PENINSULA: Cameron's Highlands, 3,500 ft.; type ♂ and 1 ♀ reared from bamboos (*Dr. H. P. Hacker*).

An extremely distinct species by coloration and by the form of the proboscis and of the male claspers. The structure of the male ninth tergite and side-piece suggests a relationship with *T. decorabilis*, Leic. This is the first occasion on which a member of this genus has been reared, and it is unfortunate that larval skins were not preserved.

***Armigeres (Leicesteria) dolichocephala*, Leic.**

Dr. Hacker reared a short series of this species from living bored bamboos, on Cameron's Highlands, 3,500 ft., associated with *L. pectinata*, Edw., and *L. annulitarsis*, Leic. These three species are very similar, all having the same peculiarly flattened thorax and strongly produced mesonotum, characteristic of some but not all species of the subgenus *Leicesteria*.

The male of *L. dolichocephala* has not previously been described. In its hypopygial characters it proves to resemble *L. magna*, Theo., rather closely, but differs in some details: the side-pieces are rather more hairy, and the claspers are much more slender, especially towards the tip, which bears only seven instead of nine spines, the first of which is very much longer than the others; external to the four spines of the basal lobe is a long fine hair.

***Armigeres (Leicesteria) annulitarsis*, Leic.**

The male of this species also has not up to the present been described, although the British Museum possesses specimens collected and presented by Capt. P. J. Barraud, obtained from larvae in bamboo stumps at Nagargali, Bombay Deccan. The Malayan examples now received from Dr. Hacker agree with the Indian ones. The hypopygium is remarkable in having a regular row of six or seven long blunt-tipped spines on the large basal lobes of the side-pieces; external to these spines is a fairly dense hair-tuft. The claspers are moderately long and slender, narrowed in the middle, and bear a row of five terminal spines, of which the first and last are distinctly longer than the others.

***Aedes (Finlaya) saxicola*, Edw. (*fluviatilis*, Leic.).**

Cameron's Highlands, 3,500 ft.; a number reared from larvae found in rock pools. Leicester's original types are lost, and the species has not been found again till now.

***Ficalbia fusca* (Leic.).**

A single female of this rare species was taken on the wing on Cameron's Highlands, 3,500 ft. This is the first record of the species since Leicester's description.

Culex hackeri, sp. n.

Head clothed mostly with whitish narrow curved and dark upright scales, the flat scales confined to the sides. Vertical bristles pale yellowish, orbitals dark. Palpi alike in the two sexes, exceeding the clypeus by rather more than twice its length, distinctly two-segmented. Proboscis longer than the front femora. Male antennae distinctly plumose, verticils with about 12-15 hairs; antepenultimate segment shorter than the preceding ones; last two segments together about two-thirds as long as the remaining segments together. *Thorax* with brownish integument, pleura apparently devoid of markings. Mesonotal scales rather small, not very dense, dark brownish, lighter round the front margin. Scutellum with a few fine brown scales on the mid lobe. Pleura unscaled. One lower mesepimeral bristle. *Abdomen* dark brown above, somewhat paler below. Hypopygium: side-piece without a definite hair-patch, lobe with three long and somewhat hooked rods, one being more flattened, and with six shorter, flattened, blunt-tipped blades, but no definite leaf. Clasper rather broad towards the base, but tapering to a rather sharp point. Aedoeagus much as in *C. khazani*, but the lobes somewhat less spiny. *Legs* dark, femora pale beneath, hind femora whitish except for the tip and a narrow dorsal line on the apical fourth. *Wings* with dark scales, outstanding ones somewhat clavate. Upper fork-cell twice (δ) or three times (γ) as long as its stem. Wing-length, 2.5-3 mm.

MALAY PENINSULA: Cameron's Highlands, 3,500 and 5,000 ft. (*Dr. H. P. Hacker*). Larvae in pools at edges of streams. Type δ , 3 other δ and 2 γ in the British Museum.

The only near relatives of this species are *C. castrensis*, Edw., and *C. khazani*, Edw., both of which differ considerably in hypopygial structure, and in having more or less distinct markings on the integument of the pleura.

B.—TWO NEW INDIAN AÊDES.

Aedes (Skusea) iyengari, sp. n.

γ . Closely allied to *A. (S.) punctipes*, Edw., differing as follows:—Abdominal tergites 5 and 6 each with a pair of small white admedian dorsal spots. Sternites all with broad apical black bands; sternite 7 all black. Legs with more numerous creamy white spots: all the femora with two or three small spots on the antero-dorsal surface before the subapical white ring; front femora also with some spots on the antero-ventral surface; all the tibiae with 5-7 spots, almost forming narrow rings; first segment of all tarsi, apart from the narrow white basal and apical rings, with two small dorsal spots, not forming rings; second, third and fourth tarsal segments narrowly whitish at the base. No white scales at the base of the fifth longitudinal vein of the wings.

BENGAL: Meenglas, Jalpaiguri, 26.vi. and 6.viii.1921 (*M. O. T. Iyengar*), 2 γ (type in British Museum, paratype in Mr. Iyengar's collection).

The sum total of the small differences from *A. (S.) punctipes*, Edw., seems to be sufficient to differentiate these specimens as a distinct species, which I have pleasure in dedicating to its discoverer.

Aedes (Aëdimorphus) nummatus, sp. n.

Head clothed entirely with broad flat scales; in the δ these are uniformly light ochreous brown, in the γ mostly dark brown, but with the eye-margins and a median longitudinal stripe ochreous brown. Orbital bristles black. Clypeus and tori dark brown, bare. Proboscis entirely dark-scaled, rather slender, equalling the front femora. Palpi dark-scaled, in δ slender, hardly more than half as long as the proboscis, segmentation indistinct; in γ about one-seventh as long as the proboscis. *Thorax* with dark brown integument; bristles black, numerous and long on the posterior

half of the scutum. Mesonotal scales narrow, dark brown, but the anterior half mainly occupied by a large, nearly round, silvery-white patch which does not quite reach the front margin. Prothoracic lobes, pro-epimera and lateral lobes of scutellum with small curved dark brown scales; median lobe of scutellum with broad flat scales, light brown in ♂, dark brown in ♀. An elongate patch of flat whitish scales on the sternopleura, and another small patch on the upper part of the mesepimera. About 4-6 post-spiracular bristles, no lower mesepimeral. *Abdomen* dark brown above, ochreous below. Hypopygium small; side-pieces a little over twice as long as broad, scaly but without definite tufts of hairs or scales, basal lobes rather long and with a few bristly hairs; claspers divided two-thirds of the way to the base into two equal, slender, slightly curved, bare prongs, the inner one bearing a moderately long terminal spine; lobes of aedeagus with several large teeth on the outer side towards the tip. Seventh segment in ♀ large, eighth small and retracted, cerci short. *Legs* dark brown, undersides of femora and tibiae light, hind femora with the basal half almost all pale, also the outer side as far as the tip, no definite knee-spots. Claws all toothed, in the ♀ the teeth very small. *Wings* with the scales all dark, out-standing ones linear. Bases of fork-cells level, upper fork in ♀ about one and a half times as long as its stem. Cross-veins separated by twice the length of the posterior. Wing-length, 2.8 mm. (♂)—3.2 mm. (♀).

BENGAL: Meenglas, Jalpaiguri, reared from larvae in tree-hole, vii.1922 (*M. O. T. Iyengar*). Type ♂ in the British Museum, allotype ♀ in Mr. Iyengar's collection.

This extremely distinct species can hardly be compared with any other in the Oriental fauna. The resemblance in coloration to *A. niveus*, Ludlow, is strong, but entirely superficial, since the structure of the male hypopygium proves that the species belongs to the subgenus *Aedimorphus* and not to *Finlaya*. In thoracic adornment, and in the reduced male palpi, it differs strikingly from all other species of the subgenus *Aedimorphus* hitherto known.

C.—CULICINE MOSQUITOS FROM NEW BRITAIN.

A small collection of Culicine mosquitos made by Mr. G. F. Hill in the island of New Britain was forwarded by him to the Imperial Bureau of Entomology for determination. So far as I am aware these are the first mosquitos recorded from this island. The following species were represented:—

Megarhinus inornatus, Walker. Rabaul and Mambung River.

Uranotaenia nigerrima, Taylor. Rabaul.

Rachionotomyia quasiornata, Taylor. Toma.

Armigeres lacuum, Edw. Beining district: Toma, 2,800 ft.

Aedes funereus var. *ornatus*, Theo. Rabaul.

Lutzia halifaxii (Theo.) var. Rabaul.

Culex sitiens, Wied. Rabaul.

C. fatigans, Wied. Rabaul.

C. catractarum, sp. n.

C. (Culicomyia) muticus, sp. n.

C. (Lophoceratomyia) fraudator, Theo. var. Rabaul.

***Megarhinus inornatus*, Walker.**

This species has been known up to the present only from Walker's types, which were redescribed by Theobald. The specimens collected by Mr. Hill in New Britain (Rabaul and Mambung River) agree well with these types, in so far as comparison is possible owing to the damaged condition of the latter. By my key to the Oriental species they would run down to *M. splendens*, Wied., to which and to *M. subulifer*, Dol., they are very closely allied, differing in the following particulars:—Scales of mesonotum more brilliantly metallic, especially at the sides. Scales of pro-epimera mostly metallic green instead of mostly white, the white ones being confined to the

lower fourth. The purple ventral stripe of the abdomen is considerably broadened on the fourth segment, and also at the bases of the third, fifth, sixth and seventh segments. The first as well as the second hind tarsal segment of the female has a well-marked basal white ring. Theobald's statement that the tarsi of the male are all dark is incorrect; even in the type there are traces left of white rings at the bases of the first two segments of the middle and hind tarsi, and these are quite distinct in the fresh specimens. The colour of the dorsal surface of the abdomen in the fresh specimens shades from green at the base to blue towards the apex.

***Rachionotomyia quasiornata* (Taylor), var.**

Closely related to *R. bimaculipes* (Theo.) (New Guinea), *R. purpurata*, Edw. (Fiji) and *R. quasiornata* (Taylor) (North Queensland), but distinguished as follows:—Integument of thorax entirely orange, somewhat shining, except for a small area of the sternopleura which is blackish, but this is obscured by the covering of silvery scales; there is also a small dark brown area in the middle of the postnotum. Scales of pronotal lobes small, flat, black; of pro-epimera very narrow, straight, black; of mesonotum narrow, straight, black. Abdomen without purple gloss; the lateral silvery markings of the fifth and sixth tergites just meeting dorsally. All femora with two distinct silvery spots, and with an anterior line on the basal third, this line being creamy on the front femora, silvery on the middle and hind pairs.

NEW BRITAIN: Toma, 1922 (*G. F. Hill*), 2 ♀.

Differs from *R. bimaculipes*, Theo., chiefly in the orange mesonotum, and from the type of *R. quasiornata*, Taylor, chiefly in the silvery basal lines on the hind femora, this last probably being a matter of individual variation.

***Armigores lacuum*, Edw.**

The numerous specimens collected by Mr. Hill agree in nearly all respects with my description, the sexual difference in the thoracic coloration being confirmed, but the underside of the abdomen is almost entirely white, except for the sternite of the seventh segment, which is black.

***Culex (Culiciomyia) muticus*, sp. n.**

Head with a very narrow rim of small greyish-white flat scales round the orbits, the greater part of the vertex clothed with dark brown upright and light brown decumbent narrow scales. Proboscis and palpi dark brown. Palpi of ♂ exceeding the proboscis by the last segment only, which is slightly longer than the penultimate, both having abundant long hairs; long segment towards the tip on the outer side with about six extremely long and slender scales, with hair-like points and slightly broadened in the middle. Palpi of ♀ distinctly two-segmented, terminal segment a little longer than the clypeus. Antennae normal. *Thorax* with the usual dull greyish integument and very small scales on the mesonotum, the scales reddish-brown in colour. Prothoracic lobes ochreous, without scales. Pleura somewhat shining, the only scales being a very few flat whitish ones on the sternopleura. One long lower mesepimeral bristle. A rather ill-defined dark brownish stripe extending from the pro-epimera to the base of the mesepimera, where it is somewhat darker, though not black; a short brown stripe across the middle of the sternopleura; remainder of pleural integument and also the coxae light greenish. *Abdomen* blackish dorsally, the segments with greyish-white basal bands of almost even width, these bands just involving the apices of some of the segments. Hypopygium: side-pieces not markedly swollen, moderately hairy. Lobe rather indistinctly divided, one division carrying a pair of straight rods, one stout and one slender, in close juxtaposition, the other division carrying a similar pair of curved spines; at the base of the lobe proximally is a single spine, and distally a rather broad but pointed pale leaf with a dark brown curved blade lying close below it. Clasper bent about the

middle, with a patch of hairs near the base and a strongly developed spiny crest on the middle third. Tenth sternites with a well-marked but slender basal arm and a semicircular flat expansion on the outer side near the tip; crest comprising about six rather stout blunt-tipped spines in a comb-like row, and a group of about 15 shorter pointed spines internally. Lobes of mesosome simple, devoid of teeth, somewhat sickle-shaped, the tips pointing outwards. Legs dark brown, femora whitish beneath; hind femora dark almost to the base above, pale to the tips on the outer side. Front and mid claws of ♂ toothed. Wings with brown scales, the outstanding ones almost linear. Bases of fork-cells practically level. Cross-veins separated by nearly twice the length of the posterior. Wing-length, 3.3-2 mm.

NEW BRITAIN: Rabaul, 1922 (G. F. Hill). Cotypes, 1 ♂ 1 ♀ in the British Museum, 1 ♂ 1 ♀ returned to the Australian Institute of Tropical Medicine.

This species is very closely related to *Culiciomyia annulata*, Theobald, known from Borneo, Malay and Ceylon. Externally the only obvious difference is that the dark spot at the base of the mesepimera is deep black in *C. annulata*, but dark brown only in the present species. The male hypopygia are also similar in most respects, but apart from some other small differences, the lobes of the mesosome in *C. annulata* are differently constructed and have a conspicuous row of teeth below. From a comparison of types, I have considered *C. annulata* to be a synonym of *C. pulla*, Theobald, described from a single female from New Guinea. It is possible that fresh material from New Guinea may prove the present species to be the true *C. pulla*, in which case the name *muticus* would fall as a synonym, and a new name be required for the Oriental form, *annulata* being preoccupied.

***Culex cataractarum*, sp. n.**

Head with a conspicuous rim of small flat white scales round the eye-margins; small flat dark ones behind these; nape clothed with narrow dark scales. Bristles all dark. Clypeus yellowish, unscaled. Palpi alike in the two sexes, exceeding the clypeus by a little more than its length, unsegmented, clothed with dark scales and rather numerous dark hairs. Proboscis dark-scaled, a little longer than the front femora, very slightly swollen at the tip in the ♂. Antennae of ♂ inconspicuously plumose, slightly longer than the proboscis; last two segments together a little over half as long as the remainder of the flagellum; flagellar segments (except the last two) slender, cylindrical, almost four times as long as broad, with a median verticil of only five or six long hairs, and several short hairs round the tip. Tori ochreous brown, unscaled. Antennae of ♀ normal. *Thorax* with the integument mostly dark brown; prothoracic lobes, a narrow ill-defined band extending back from them to the wing base, and the lower half of the sternopleura light ochreous. Scutum and scutellum with long black bristles and scanty narrow, curved, dark brown scales. Prothoracic lobes and pleura without scales, the latter somewhat shining. Four pro-epimeral, two or three upper mesepimeral and no lower mesepimeral bristles. *Abdomen* dark brown, unmarked, venter very little lighter than the dorsum. Hypopygium ochreous. Side-pieces moderately hairy, without scales; lobe simple, with only three long and slightly bent rods; leaf absent. Clasper rather short, somewhat sickle-shaped, tapering, extreme tip slightly recurved, without crest or fringe. Tenth sternites without basal arm, tips with only about six spines, three of them stout and blunt-tipped. Halves of mesosome simple, smooth, bluntly pointed. *Legs* dark brown, lower surfaces of femora whitish, also the lateral surfaces of the hind femora almost to the tip. First segment of hind tarsus longer than the tibia. Larger claw of front legs of ♂ with a median tooth, other claws all simple. *Wings* with the scales all brown, those towards the tip of the wing spatulate. Upper fork-cell more than twice as long as its stem. Cross-veins separated by nearly twice the length of the posterior. Halteres with pale stem and dark knob. Wing-length, 2.2-5 mm.

NEW BRITAIN: Rabaul, 1922; on rocks under waterfall (*G. F. Hill*). Cotypes, 4♂ 1♀ in the British Museum, 2♂ returned to the Australian Institute of Tropical Medicine.

This is the first species of *Culex* with short male palpi to be described from the Australasian region. It differs conspicuously from the five known Oriental species in the structure of the male antennae and hypopygium and in the scaling of the head.

D.—A NEW HODGESIA FROM NEW GUINEA.

Hodgesia spoliata, sp. n.

Head mostly black, but with a rather broad and continuous bluish-silvery margin to the eyes, somewhat broader at the vertex. Eyes separated by an unscaled line. Proboscis and palpi blackish, the latter scarcely reaching beyond the clypeus. *Thorax* with the integument almost entirely shining black, the lower part of the pro-epimera greyish, the scutellum brown, and a small area round the roots of the wings ochreous. Mesonotal scales small, narrow and black. Scutellar scales small, flat, black, difficult to see. Prothoracic lobes entirely covered with silvery scales; a large patch of silvery scales at the base of the mesepimera and pteropleura, and a small one close to the mid coxae. One strong black lower mesepimeral bristle; the usual two long pro-epimeral bristles also present. *Abdomen* greenish black dorsally, somewhat lighter ventrally, devoid of silvery markings. *Legs* purplish black; coxae pale yellow; front and mid femora pale on about the basal half, hind femora whitish except at the extreme tip, the dark scales of which extend basally for only a short distance on the upper surface. *Wings* normal; *Rs* with a short spur at the angle; upper fork-cell scarcely longer than its stem; bases of the two forks almost level. Halteres blackish, lighter at the base. Wing-length, 2 mm.

NEW GUINEA: Mekeo district, 1922 (*G. F. Hill*). Cotypes, 3♀ in the British Museum, 1♀ returned to the Australian Institute of Tropical Medicine.

By the colour of the abdomen and legs this is allied to *H. malayi*, Leic., and *H. ampyx*, Dyar, but differs in the almost entirely black thorax.

E.—A NEW RACHIONOTOMYIA FROM TASMANIA.

Rachionotomyia cephasi, sp. n.

♀. *Head* dull purplish brown; a dull white patch on each side, not continued round the front. Clypeus dark brown, bare. Palpi dark brown, exceeding the clypeus by about twice its length. Proboscis blackish, slender, equalling the front femora or the abdomen in length. *Thorax* with the integument almost uniformly dark brown, the scutellum lighter. Pronotal scales flat and white; pro-epimeral flat and dark brown; mesonotal (scutal) dull dark brown, rather narrow and slightly curved; scutellar broad, flat, dark brown; pleura with a band of flat white scales extending longitudinally below the margin of the mesonotum, and a patch occupying the posterior edge of the sternopleura and the lower part of the mesepimera, the space between these scaly areas being bare. One (?) pro-epimeral bristle; three (?) spiracular; three or four sternopleural, one being long and dark, the others short and pale. Mesonotal bristles present but rather short. *Abdomen* dark brown above, whitish below. *Legs* dark brown, under sides of femora somewhat lighter towards the base; all femora with small white knee-spots, most distinct on the hind legs. Front and mid tibiae with small white apical spots; hind tibiae with a conspicuous white apical patch on the outer side, longer than the diameter of the tip of the tibia. Mid tarsi indistinctly paler towards the tips. Hind tarsi with the last two segments entirely white, also the tip of the third, a white ventral line extending the full length of the second and third segments. Claws normal. *Wings* with all the scales dark brown, outstanding ones

long and linear, the others broad and rather large. Upper fork-cell over three times as long as its stem, its base nearer the base of the wing than that of the lower. Wing-length, 4 mm.

TASMANIA: Mole Creek, Feb. 1923 (*Cephas L. Edwards*). Type and one other ♀ in the British Museum.

This species, though apparently nearly allied to *R. atra* (Taylor) of New Guinea, is very distinct from this and the other Australian species, indeed from all other species of the genus (unless the peculiar *argyropus*, Walker, of New Zealand is to be referred here) by the coloration of the hind tarsi. In the length of the proboscis it is intermediate between true *Rachionotomyia* and *Rachisoura*, thus rendering the final union of these genera still more probable. The species is named in honour of the writer's father, whose small collection of insects, made during a short visit to Tasmania, contains several interesting additions to the British Museum collections.

F.—A NEW TAENIORHYNCHIUS FROM PALESTINE.

Taeniorhynchus (Coquillettidia) buxtoni, sp. n.

Head with the decumbent scales pale ochreous, upright scales dark brown. Proboscis and palpi entirely dark-scaled; proboscis slightly longer than the front femora; palpi about one-fifth as long as the proboscis. *Thorax* with reddish brown integument. Scales of prothoracic lobes, pro-epimera and mesonotum golden brown, lighter on and in front of the scutellum. *Pleurae* with small patches of dull ochreous flat scales; about 6 pro-epimeral and 3-4 lower mesepimeral bristles. *Abdomen* mostly dark-scaled dorsally, with a more or less pronounced purple gloss; tergites with lateral basal creamy spots, which tend to form narrow complete bands, especially on the second segment; no pale scales scattered on the dark parts. *Legs* mostly dark, the tarsi entirely so, the dark scales with a slight purple gloss. Femora ochreous beneath and towards the base, not distinctly mottled. Femora and tibiae with conspicuous creamy apical spots. Mid and hind tibiae with indications of a narrow longitudinal pale stripe on the anterior or outer side. *Wings* with the scales all dark, and on the average markedly narrower than in *T. richiardi*. Bases of fork-cells practically level. Halteres ochreous, knot somewhat darker. Wing-length, 4 mm.

PALESTINE: Huleh, Jordan Valley, 3.ix.1922 (*P. A. Buxton*). Cotypes, 4 ♀, presented to the British Museum by the Imperial Bureau of Entomology.

This species differs in many details of coloration, notably in the dark tarsi, from *T. richiardi* (Fic.), the only species previously known from the Palaearctic region.

NOTES UPON THE HABITS OF CEYLONESE AMBROSIA-BEETLES.

By EDWARD R. SPEYER, M.A., F.E.S.

(PLATES I-VI.)

The ambrosia-beetles of Ceylon comprise a number of genera of SCOLYTIDAE and PLATYPODIDAE. It is proposed only to deal with beetles belonging to the former family which are included in the subfamily CRYPHALINAE, adding a few notes on the Platypodids.

In passing, however, it may be stated that 62 described species of SCOLYTIDAE, and 12 of PLATYPODIDAE, have been recorded from Ceylon. Of the SCOLYTIDAE no less than 44 species belong to the subfamily CRYPHALINAE, and 32 of these to the single genus *Xyleborus*, which appears to contain only ambrosia-feeders. Of the PLATYPODIDAE, three species belong to the genus *Crossotarsus* and nine to the genus *Platypus*. The SCOLYTIDAE proper are represented in all by 17 genera.

Although these two families of beetles had been collected in Ceylon for more than 30 years previously, Mr. E. E. Green was the first entomologist to make notes upon their habits, from the year 1899 onwards, and we now have a more or less continuous record up to the present time. In spite of this, we have details of the bionomics of only a very few species, the reason being in some measure due to the confusion in the classification, but mostly to the great difficulty encountered in studying the insects, and the amount of time required in tracing their borings in the woody portions of trees and shrubs which they have entered. Indeed it not infrequently happens that the labour of a whole day spent in laying open their tunnels results in obtaining only two or three of the insects.

Family SCOLYTIDAE.

Genus *Xyleborus*.

By far the most numerous in species so far as Ceylon is concerned, this genus is distributed throughout the island, but is most frequently met with in the wet hilly districts, from sea-level to 5,000 ft. elevation, above which we have no records. The species so far agree in their habits that they all enter the trunks and branches of trees and shrubs, and that one female only is concerned in the construction of the complete gallery.

The female flies to a suitable place on a trunk or stem, and proceeds to cut a circular hole in the bark,* driving a tunnel, very slightly larger in diameter than herself, horizontally into the sap-wood, and always ejecting the borings with her legs. In what we will call the typical form of gallery this entrance tunnel, after pursuing its course for a few millimetres into the wood, is turned at an angle to the left or right, and continued as a semicircular tunnel in the same horizontal plane for a distance of at least eight or ten millimetres. The beetle now returns to the origin of this and makes a similar tunnel in the opposite direction. Returning again to the origin of these, two further branching tunnels, of an even bore, and all in the same horizontal plane, are constructed towards the centre of the stem, resulting in a tree-like formation (fig. 1). If many beetles make their galleries in close proximity in the same stem, their tunnels never break into one another, even though the insects are of the same species. A species that makes such a typical gallery in the thick trunk of a tree will modify the structure of the gallery when boring in a thin branch or twig.

In some species, branches of the original tunnel may be widened later into capacious brood-chambers in which the larvae feed and pupate (often misnamed the "death chamber"). The eggs are laid in groups of 5-10 in the tunnels, not necessarily at their

* The beetle walks round in a circle while cutting the entrance, the abdomen describing a circle concentric with the latter, and shears off small fragments of the plant tissues with the mandibles.

ends, and never in any specially constructed niche or pocket. They are white and shining, and, being sticky, adhere together and to the walls of the tunnels. The number of ecdyses during development of the larvae, which are white, legless, and sparsely hairy, has not been determined. The pupae, also white, have no pupal chambers, and the larvae never widen or extend the tunnels. The male beetles are, in most species, very much smaller than and differently shaped from the females, and take longer to assume the adult coloration. Further, they are without wings, but do not necessarily die in the gallery, creeping out at the original entrance-hole, probably at night. It is said that the males of a brood fertilise their sisters, but this has not been proved; it is equally possible that parthenogenesis occurs, for large broods have been observed where no male was present.

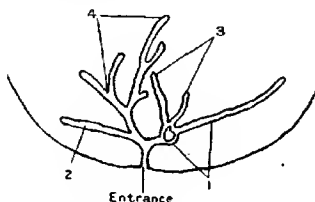


Fig. 1. Gallery of *Xyleborus perforans* in trunk of *Hevea brasiliensis*, transverse section; the numbers indicate the order in which the tunnels are constructed.

There seems to be a definite proportion of males to females in the broods of any one species. In no case have the males been observed to construct any portion of a gallery, in spite of the fact that they have well-developed mandibles. The female offspring of the brood all emerge through the original entrance-hole made by their parent; the latter generally dies within the gallery, though she may live for some weeks after emergence of her offspring. If the entrance-hole of a gallery is stopped up, the adult beetles die within, for they are not endowed with the instinct for boring their way out.

The host-plants chosen by any one species are usually numerous, and in no way related botanically; it is possible in most cases, however, to assign a principal host-plant to a species.

It is a curious fact that practically all records of entry into plants relate to trees and shrubs that have been imported at one time or another into Ceylon. In 1918, for instance, a plot of *Tephrosia vogelii* plants were grown from seed at the Botanic Gardens, Peradeniya, in connection with green-manure experiments. When these had flowered and attained a height of some 15 ft., they were heavily attacked by two species of *Xyleborus*, and a Scolytid belonging to a genus and species new to science.

Though most species enter dying plants or recently cut branches, one or two attack living and apparently healthy plants. Trees affected by specific pathogenic fungi seem to attract, though rather indefinitely, certain species, while other species appear to show a distaste for their host-plants if the latter are attacked by certain of these fungi.

I must here tender my thanks to Colonel F. Winn Sampson for the trouble he has kindly taken in identifying a very large collection of specimens from Ceylon.

Species that Attack Living Plants.

***Xyleborus fornicatus*, Eichhoff.**

Notorious as a serious pest of the tea-plant (*Camellia thea*, Link) and known as the "shot-hole borer of tea," this beetle is by far the commonest Scolytid in Ceylon, and ranges from sea-level to 5,000 ft. elevation. The principal host-plant of the insect is, however, the castor plant (*Ricinus communis*, L.) (Plate i, fig. 1). Though three-quarters of the area under tea cultivation is affected, the tea plantations of some

districts in which castor is heavily infested are entirely free from the beetle, which becomes uncommon in tea at an elevation above 4,500 ft.

In more than one locality tea-bushes will be riddled with galleries up to a certain point on each side of the lower portion of a valley, but above this, though well within the limits of favourable altitude, the plants will be entirely free from the pest. The only explanation that can be given is that the plants in the infested region have, as it were, dropped below a certain standard of vitality, and that no amount of artificial cultivation will, so far as the beetle is concerned, bring back the resistant powers of the plant; it is possible that the beetles are unable to grow the ambrosia fungus in localities where the plants are resistant.

In addition to choosing a very large number of trees and shrubs (a list of which is given below) in which to construct their galleries, especially Leguminosae, the insect will make successful galleries in the thicker cut branches of the dadap (*Erythrina lithosperma*, Bl.) and the country almond (*Terminalia catappa*, L.).

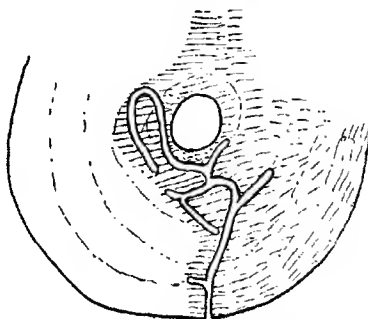


Fig. 2. Cross-section of branch of country almond (*Terminalia catappa*) showing a gallery of *X. fornicatus*; the shaded portion was attacked by fungus prior to the construction of the gallery.

There are also a few records to hand where obviously diseased plants, or parts of plants, have afforded a breeding-place, even to the extent of forming a definite attraction to the insect. These are:—

1. A tea-bush (*Camellia thea*, Link) killed by the fungus *Rosalinia*, and heavily infested after death; Bandarawala, 4,500 ft., 7th March 1916.
2. Dead branches of cacao (*Theobroma cacao*, L.) infected with fungi; Peradeniya, 1,600 ft., 3rd January 1914, and Kandy, 2,000 ft., 1st April 1915.
3. Dead branches of rubber (*Hevea brasiliensis*, Müll.) attacked first by canker; Nawalapitiya, 1,000 ft., 30th March 1905, and Gampola, 2,000 ft., 2nd December 1909.
4. Dying branches of country almond (*Terminalia catappa*, L.) attacked by the fungi *Rosalinia* and *Diplodia*; Peradeniya, 1,500 ft., 20th February 1917 (fig. 2).
5. Branches of *Albizia moluccana*, Mig., attacked by various fungi; several records from 1,000 to 3,000 ft. elevation.
6. Trunk and branches of *Ficus nervosa*, Heyne, large numbers of the beetles entering portions attacked by fungi, including *Rosalinia* and *Diplodia*; Udupuscellawa, 4,100 ft., 30th December 1918 (fig. 3).

It has, unfortunately, been impossible to determine if the presence of any particular fungus has been the cause of attraction to the beetle in any of these cases, as the primary cause of disease has laid the attacked portions open to entry by other fungi.

In thick trunks of castor, tea, dadap, etc., the structure of the gallery made by the female beetle conforms to that described for the genus, but in thinner branches the entrance-tunnel runs obliquely into the sap-wood and gives off two circular horizontal tunnels on nearing the cambium of the other side, thus rendering the branches very liable to fracture. After this two additional tunnels are always constructed, one running vertically upwards, and the other vertically downwards in the pith of the branch for a total distance of some 70 mm. In some thin twigs these vertical tunnels may be the only ones made, but such is not very often the case.

The eggs are usually deposited in batches of five or six up to a total of 30 in the horizontal tunnels.

The structure of the gallery is modified when portions of the plant tissues in the region of the tunnels have been infected previously by fungi, and their course is then adapted to the obtaining of suitable moisture conditions, the actually infected regions, however, being avoided (fig. 3).

The wood-tissues surrounding the gallery are coloured of a deep purple tint, often for a distance of four inches above and below, this being due probably to hyphae of the fungus *Ceratostomella*.

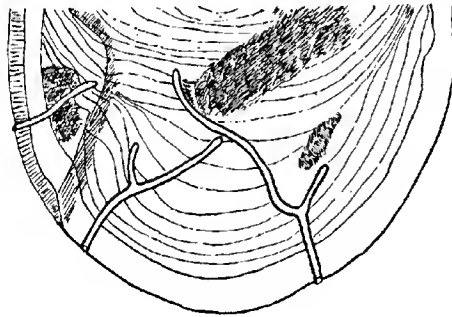


Fig. 3. Cross-section of branch of *Ficus nervosa* showing galleries of *Xyleborus forficatus* and patches of the *Diplodia* fungus.

The ambrosia mycelium grown by *Xyleborus forficatus* consists of comparatively long, sparsely septate, narrow hyphae; curiously enough the rounded conidial bodies characteristic of other ambrosia fungi have not been observed. In addition, spores of *Monacrosporium* are constantly found in the tunnels when this insect is excavating the gallery, and this fungus occurs also amongst the ambrosia hyphae. There is a possibility of the *Monacrosporium* being a free-living phase of the ambrosia fungus, especially as it occurs in galleries which have been vacated by the insect.

The proportion of males to females produced in a brood is as 1 : 5, and the males do not bore into plant-tissues. They are not usually found dead in the tunnels after emergence of the females, so it must be concluded that they creep out on the stems, probably at night.

X. forficatus is not attracted to light at night, but sometimes settles on white objects in the heat of the day, when emergence and flight of the females take place.

The broods occupy roughly six weeks in their development. There appears to be no well-marked seasonal activity of the species, which is found plentifully throughout the year, but is less common, perhaps, in years when the rainfall is below the average.

The average length of 215 female beetles collected from various plants was found to be 2.44 millimetres, and of 30 males 1.54 millimetres. These ranged themselves as follows :—

Plant.	Female Beetles.		Male Beetles.	
	Number Examined.	Average Length.	Number Examined.	Average Length.
<i>Ricinus communis</i> , L.	70	2.5 mm.	13	1.6 mm.
<i>Erythrina lithosperma</i> , Bl.	24	2.5 "	2	1.4 "
<i>Terminalia catappa</i> , L.	7	2.5 "	—	—
<i>Tephrosia vogelii</i> ..	6	2.5 "	1	1.5 "
<i>Poinciana regia</i> , Boj.	1	2.5 "	—	—
<i>Camellia thea</i> , Link.	70	2.4 "	13	1.5 "
<i>Albizzia moluccana</i> , Mig.	18	2.4 "	1	1.6 "
<i>Crotalaria striata</i> ..	6	2.4 "	—	—
<i>Tephrosia candida</i> , B.C.	5	2.4 "	—	—
<i>Hevea brasiliensis</i> , Müll.	2	2.4 "	—	—
<i>Lantana aculeata</i> , L.	6	2.3 "	—	—

There are thus two races of the beetle, a large and a small one, both of which occur in *Albizzia moluccana* with equal frequency, but the former predominates in castor and dadap. The small race predominates in the tea-plant, in which we have but few records of the large race occurring, and these refer to cases where tea is growing in close proximity to castor or dadap in districts where the insect is rare in the former and common in the two latter plants.

We therefore have reason to believe that the large race in castor gives rise constantly to the small race in other plants, and that this small race is gradually predominating over the original one.

The following is a list of plants from which *Xyleborus fornicatus* has been recorded :—

Natural Order.	Name of Plant.	Local Name.	Elevation in feet.
Bixaceae ..	<i>Bixa orellana</i> , L.	Annatto ..	?
Ternstroemiaceae	<i>Camellia thea</i> , Link.	Tea ..	100-5,000
Sapindaceae ..	<i>Allophylus cobbae</i> , Bl.*	.. ..	1,600
Sterculiaceae ..	<i>Theobroma cacao</i> , L.	Cocoa ..	1,600-2,000
Rutaceae ..	<i>Citrus aurantium</i> , L.	Orange ..	2,000
Leguminosae	<i>Albizzia moluccana</i> , Mig.	.. ..	100-3,000
	<i>Cassia alata</i> , L.	.. ..	1,600
	<i>Crotalaria striata</i> ..	.. ..	2,000
	<i>Desmodium cephalotes</i> ..	.. ..	1,600
	<i>Erythrina lithosperma</i> , Bl.	Dadap ..	1,600-4,500
	<i>Poinciana regia</i> , Boj.	Flamboyante ..	4,000
	<i>Tephrosia candida</i> , D.C.	Boga medalloa ..	1,000-4,000
	<i>Tephrosia vogelii</i> ..	.. ..	1,600
Rosaceae ..	<i>Photinia japonica</i> , Linell	Loquat ..	3,000
Combretaceae ..	<i>Terminalia catappa</i> , L.	Country almond ..	1,600
Myrtaceae ..	<i>Psidium guayava</i> , L.	Guava ..	?
Melastomaceae ..	<i>Melastoma malabathricum</i> , L.*	.. ..	1,000
Rubiaceae ..	<i>Cinchona calisaya</i> , Wildn.	Cinchona ..	?
Verbenaceae	<i>Clerodendron siphonanthus</i> , Br.	.. ..	1,600
	<i>Lantana aculeata</i> , L.	Lantana ..	1,000-4,000
	<i>Petraca volubilis</i> , Tacq.	.. ..	1,600
Lauraceae ..	<i>Persea gratissima</i> , Gaertn.	Avocado pear ..	1,600
Proteaceae ..	<i>Grevillea robusta</i> , A. Cunn.	Silky oak ..	1,600-4,000
Euphorbiaceae	<i>Hevea brasiliensis</i> , Müll.	Para rubber ..	1,000-2,000
	<i>Ricinus communis</i> , L.	Castor ..	100-6,000
Urticaceae ..	<i>Ficus nervosa</i> , Heyne.*	.. ..	4,100
Palmaceae ..	<i>Caryota urens</i> , L.*	Kitul palm ..	4,000

Of the above plants only four, those marked with an asterisk, are indigenous to Ceylon, and but one record has been obtained from each; all the other trees and shrubs have been imported into the island at various times.

***Xyleborus compactus*, Eichhoff.**

This very minute *Xyleborus* is known as the "bubuk" in Java, where shoots of the coffee plant are commonly infested.

In Ceylon the beetle has been recorded from nine different plants, including camphor (*Cinnamomum camphora*, Nees.), tea (*Camellia thea*, Link.), coffee (*Coffea robusta* [arabica, L.]), and an orchid (*Dendrobium*), and is specially addicted to nursery seedlings of tea, cotton-tree (*Bombax malabaricum*, D.C.) and large-leaved mahogany (*Swietenia macrophylla*, L.), to the latter of which considerable damage has resulted. It is probable that the avocado pear (*Persea gratissima*, Gaertn.) is the principal host-plant. Leguminous plants and rubber seem to be avoided by the insect, which ranges from sea-level to 3,000 ft. elevation.

In nearly all the plants attacked only thin stems and twigs are selected, but in the avocado pear branches of an inch in diameter are chosen; into these an entrance tunnel is driven, dividing into two short horizontal branches, which are widened by the female until they coalesce and form a comparatively large brood-chamber (Plate i, fig. 2). In thin tea and coffee shoots a small horizontal chamber is thus constructed and vertical galleries made subsequently in the pith. Seedlings are usually entered near the ground-level. In large-leaved mahogany seedlings, however, the gallery pursues a simple vertical course up and down the pith, without widening.

In the case of the attack mentioned in *Dendrobium* the plant was probably diseased previously (fig. 4), and an old tea-plant dying of *Rosalinia* fungus was heavily infested by the beetle, though none of the surrounding healthy plants had been entered. Otherwise the plants recorded as attacked have always been healthy, so far as it is possible to judge.

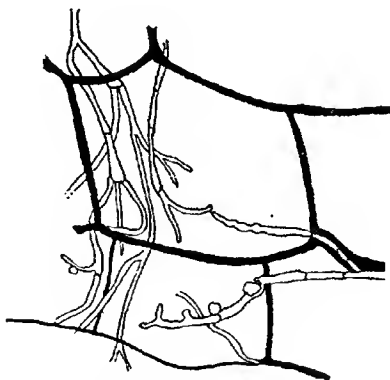


Fig. 4. Hyphae of *Ceratostomella* in wood cells of *Dendrobium* in the region of a gallery of *Xyleborus compactus*.

As many as 61 individuals have been recorded in one gallery—all the offspring of a single female. The proportion of males to females appears to be as 1 : 6.

The seasonal activity is well marked and practically restricted to the wet season from October to January, with a minor occurrence in May. What becomes of the beetle during the intervening periods is a problem which applies also to other Scolytid beetles in Ceylon. It has been stated (Agric. Bull. Fed. Malay States, N.S. i, no. 7, 1913) that the beetle always disappears after a serious attack without special measures

having been taken for its suppression. The cause is put down to a check by natural enemies in the shape of a small Chalcid. Natural enemies, however, have not been observed in Ceylon, and it is much more probable that the disappearance is due to the natural course of the seasonal activity. A curious physiological reaction is set up in the tissues of many plants (especially coffee and avocado pear) by the entry of the beetle: a copious exudation takes place in the region of the borings, and results in a deposit of calcium oxalate on the bark round the entrance holes. In the large-leaved mahogany the exudation is represented by a flow of a resinous substance from the walls of the tunnels, but this does not interfere with the development of the broods.

The staining of the wood-tissues in the neighbourhood of the galleries is exceptionally deep, and hyphae of a fungus, probably *Ceratostomella*, have been found in the wood-cells. The ambrosia fungus grown in the galleries consists of minute club-shaped hyphae, which later become septate and branched, giving off, finally, rounded conidia, with rather thick cell-walls (fig. 5).



Fig. 5. Ambrosia hyphae and conidia from gallery of *X. compactus* in twig of *Coffea robusta*.

Xyleborus compactus is not attracted to light, and probably flies in the daytime.

***Xyleborus morigerus*, Blandford.**

Though the female of this species is distinctly larger than that of *X. compactus*, the male is exceedingly minute.

It has been recorded once from diseased rubber bark (*Hevea brasiliensis*), dying branches of honeysuckle (*Lonicera caprifolium*) and the legume, *Tephrosia vogelii*, after flowering. In common with *X. compactus*, however, it has been found in tea-seedlings, *Dendrobium* and avocado pear.

The development of the brood is exceedingly rapid, occupying little more than a week. So far as gallery construction and general habits are concerned this species resembles *X. compactus* so closely that we are rather inclined to think that the two might represent dimorphic forms of the same insect.

***Xyleborus arquatus*, Sampson.**

A rare species, recorded but thrice, and apparently peculiar to Ceylon. The principal host-plant is camphor (*Cinnamomum camphora*) (fig. 6), and a few females were found constructing galleries in cacao branches which had been cut from the trees, but no eggs were laid in these.



Fig. 6. Ambrosia hyphae and conidia from a gallery of *Xyleborus arquatus* in camphor.

Mr. Green has the following note upon specimens collected at Hewaheta (elevation about 3,000 ft.) on 17th November 1906:—

"Perfectly sound camphor branches of over an inch down to twigs less than one-quarter inch are perforated. The bark for some distance above and below each point of attack is discoloured (deep brown). The stain penetrates into the wood and causes the death of the smaller branches. In deserted galleries—in the larger branches—the central wood-area is dead and decayed, but the bark appears to have recovered. Galleries transversely circular, and restricted to the immediate area; they do not run up and down the branch. . . . No males have been observed."

On 1st November 1917 the camphor trees at Peradeniya, 1,500 ft., were attacked by this species, but the female beetles are less than half the size of Mr. Green's specimens, though otherwise identical; they were found only in small twigs of dead branches, the galleries running up and down the pith for a distance of some 42 mm. (Plate iv, fig. 3). The highest number of individuals found in a gallery was eleven, exclusive of the parent beetle. One or two very minute males were present. The larvae are of a yellowish colour. The cacao branches referred to also contained these small females in vertical galleries in the pith (Peradeniya, 17th January 1918).

It would seem that the beetle has degenerated in size since it was first recorded, and has taken to boring into dying branches containing sufficient moisture. This is paralleled by the various races of *Xyleborus formicatus* found in the different plants which it attacks, though the range in size is not so great as in *X. arquatius*.

Species attacking Dying Plants only.

***Xyleborus semiopacus*, Eichhoff.**

Branches of diseased rubber (*Hevea brasiliensis*), silky oak (*Grevillea robusta*, A. Cunn.), stems of diseased sugar-cane (*Saccharum officinarum*, L.), and trunks of diseased toona (*Cedrela toona*, Roxb.), are entered by this species, of which *X. semiopacus*, Blandford, is probably only a variety. It will also make successful galleries in the trunks of tea-bushes previously attacked by the fungus *Rosalinia* and in branches of rubber affected by *Diplodia*. Female beetles may be obtained in numbers if pieces of bark be removed from the trunks of silky oak; they are definitely attracted to the exposed surface from 6–12 days after the operation, but they fail to make successful galleries. They will also settle on white objects at sundown, but are not attracted to light.

The gallery is of the horizontal type, but with few branches, one of which is sometimes widened into a brood chamber (Plate ii, fig. 1).

The insect has been found at elevations between 1,000 ft. and 4,000 ft. above sea-level, but the male has not been recorded from Ceylon.

***Xyleborus interjectus*, Blandford.**

This beetle is the largest of the genus in Ceylon, and seems to be confined to an altitude of about 1,500 ft. It will occasionally enter trunks of rubber trees (*Hevea brasiliensis*) that have been injured by fire so as to stop the flow of latex, in which case many are found drowned in the latex that exudes from the sides of the wound. Rubber seems to be the principal host, though decaying trunks of dadap (*Erythrina lithosperma*) and citrus (*Citrus aurantium*) are also chosen.

Of late the insect seems to have become common, being recorded from trunks of dying candle-nut trees (*Aleurites triloba*), bread-fruit (*Artocarpus incisa*), and diseased cacao branches. It is seldom associated with PLATYPODIDÆ when attacking a diseased or injured tree. The male, though hitherto undescribed, is not uncommon. The species is not attracted to light or to white objects.

The extensive galleries are of the typical horizontal type, much branched, extending as much as three inches into the wood, and occupying an area of seven square inches (Plate iii).

Xyleborus obliquecauda, Blandford, recorded once from cankered rubber bark, and *X. lewisi*, Blandford, are probably varieties of this species, which may be found from September to the end of February.

***Xyleborus asperatus*, Blandford.**

The beetle is common at an elevation of 1,500 feet in dying or moist dead branches of *Albizzia moluccana*, Mig., and has a habit of entering the smaller branches (10-30 mm. diameter) at the tops of the tallest trees. These branches easily break off in the wind and fall to the ground. A single record relates to the insect making a successful gallery in the trunk of a diseased black wattle (*Acacia decurrens*, Willd.) at an elevation of 4,500 feet. Some of the offspring of the beetle had attained maturity a month after their parent had begun boring, but development is probably much more rapid at lower elevations.

The gallery differs from that of all other Ceylon Scolytids, as all the branches, some five in number, lie in a vertical direction, though not in the same plane (Plate ii, figs. 2, 3).

The eggs are laid in clusters at the ends of these vertical tunnels, and not in small offshoots from the latter, which occur frequently. The first egg-cluster comprises about 10 eggs, the second 15, and the third 15 again, so that one parent may produce more than 40 offspring. The proportion of males to females is usually as 2 : 5, and some of the males remain in the gallery, where they die after emergence of the females. Complete galleries may occupy an area of 75 mm. length and 20 mm. depth.

The greatest activity is displayed in the two wet seasons, no record being to hand from December to March, or again from June to September.

***Xyleborus comptus*, Sampson.**

Superficially resembling *X. fornicatus*, this species has been recorded but twice from diseased Para rubber (*Hevea brasiliensis*), at an elevation of 1,500 feet, by Mr. E. E. Green.

***Xyleborus perforans*, Wollaston.**

X. parvulus, Eichh., *X. submarginatus*, Blandf., *X. dilatatus*, Eichh., and *X. affinis*, Eichh., are probably all varieties of *X. perforans*. They make galleries of the typical horizontal branched type very deep into the wood (fig. 1), in the trunks of injured and dying trees, especially rubber (*Hevea brasiliensis*) which has been previously attacked by fungi, such as *Corticium* or *Diplodia*.

They fly often in swarms at sundown, and are then attracted to white objects, and they also fly to light at night. *X. perforans* may be obtained in numbers if a portion of the bark is removed from the trunks of *Grevillea robusta* or *Cedrela toona*; it is also attracted occasionally to tea which has previously been infested with the fungus *Rosalinia*.

The beetles may be found at all times of the year except in May and June. *X. perforans* ranges from sea-level (in the coconut palm, *Cocos nucifera*, L.) to an elevation of 5,000 feet (in *Acacia decurrens*, Willd.), but the others seem to be restricted to an altitude below 3,000 feet, and are much less common. They rarely enter Leguminous trees.

***Xyleborus bicolor*, Blandford.**

A dozen adult females and some larvae were taken from galleries in a dead branch of *Albizzia moluccana*, Mig., in a valley near Ratnapura, where several curious Scolytids have been collected (elevation 3,000 feet).

The gallery resembles somewhat that of *X. asperatus*, Blandford, for the tunnels made as extensions of the entrance tunnel lie entirely in an horizontal plane, but at least one of them is widened into a narrow chamber similar to the brood-chamber of *X. exiguus*, Walk. (Plate iv, fig. 1). Twelve adult females were taken from single gallery.

***Xyleborus exiguus*, Walker.**

A small and uncommon species which enters the trunks of diseased Para rubber. The gallery is characteristic, the entrance tunnel leading to a very spacious but narrow chamber constructed either vertically or horizontally in the wood; the chamber, in which the brood develops, is continued into a slightly curved, short tunnel (Plate iv, fig. 1). As many as 20 individuals have been taken from a single gallery. The beetles fly in swarms in the evening at sundown and settle on white objects spread on the ground; they are also attracted to light at night. The male has not been found in Ceylon.

The insect has been found between elevations of 1,000 and 3,000 feet, and specimens collected latterly are larger than those taken in 1909, closely resembling *X. sphaenos*, Sampson, a Uganda species.

***Xyleborus discolor*, Blandford.**

Albizia moluccana is the chief host of this peculiar beetle, which is found rather commonly between elevations of 1,000 and 4,000 feet. Though recorded from coffee, camphor and cacao, it is doubtful if successful galleries are made in these plants. In August 1903 it was reported that thousands of young rubber plants were attacked by the insect, but it is probable that some fungus disease had affected them first; at any rate, since then the beetle has only been found in diseased branches of rubber and of the silky oak (*Grevillea robusta*).

The beetle is essentially a thin branch or twig borer, and makes galleries in diseased and wind-broken branches of *Albizia moluccana*, from a half to one and a half inches diameter. The gallery is started in the branches when they are still green, but not before their leaves have begun to fade; it is very limited in extent, and resembles rather that of *X. compactus* or *X. morigerus* in general construction. The entrance leads to a circular horizontal tunnel in which a batch of eggs is laid; this appears to be widened into a chamber after oviposition, and a short vertical tunnel is then made either upwards or downwards (sometimes both) from the inner end of the entrance tunnel (Plate iv, fig. 2). The female does not often produce more than eight offspring.

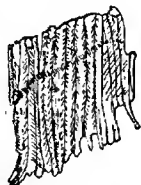


Fig. 7. Plate of wood ejected from a gallery by a ♀ of *Xyleborus discolor*. × 40.

The beetle is especially attracted to dying branches of honeysuckle (*Lonicera caprifolium*), as is shown by some experiments carried out at Peradeniya in December 1917. The ringing of the branches is not sufficient to cause the death of the leaves, and the beetles will only fly to branches not less than three and not more than six days after they are cut from the plant. They fly in the daytime, but enter the branches at night. The borings ejected consist (as in other species) of irregular plates of wood-tissue (fig. 7), amongst which no fungus spores could be found.

The gallery is completed and the eggs laid two days after entry, and the pupal stage of the offspring is reached three days after the laying of the eggs. This very rapid development is an adaptation to the supply of moisture, which must decrease rapidly in the dying tissues.

In the case of the galleries kept under observation 11 young beetles emerged from each. A moulted larval skin, and what were evidently pellets of larval excreta, were ejected from one of the galleries by the parent beetle (fig. 8). The pellets were of a black colour, and adhering to them were some adventitious *Diplodia* spores; they consisted of a mass of collapsed fungus cells, but it was not possible to tell whether these were the mycelia or conidia of the ambrosia fungus. There appeared, however, to be some undigested conidia.

The insect is found in the wet seasons, and is not recorded from the months of May to July.

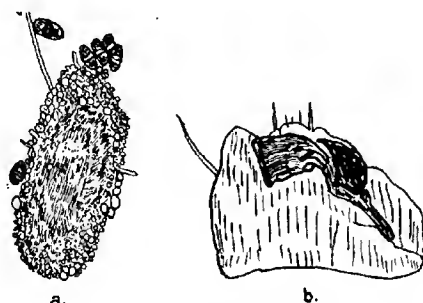


Fig. 8. Pellets ejected from its gallery by a ♀ of *X. discolor*: a, pellet of fungus spores, the large ones being those of *Diplodia*; b, portion of a moulted larval skin.

The following ambrosia feeders of this genus have been recorded from Ceylon, but we have no details as to their habits:—*X. amputatus*, Bldf., *X. dentatus*, Bldf., *X. distinctus*, Mot., *X. fraternus*, Bldf. (probably identical with *X. formicatus*), *X. indicus*, Eich., *X. laticollis*, Bldf., *X. lewisi*, Bldf., *X. mancus*, Bldf., *X. obliquecauda*, Mot., *X. piceus*, Mot., *X. semigranosus*, Bldf., *X. seminitens*, Bldf., *X. submarginatus*, Bldf. (variety of *X. parvulus*, Eich.), *X. testaceus*, Walk. (variety of *X. perforans*), *X. truncatus*, Erich., *X. tuberculatus*, Mot., *X. tachygraphus*, Zimm., *X. habercorni*, Eggers, and (?) *X. scabripennis*, Bldf., from *Mimusops hexandra* in the northern dry zone.

Family PLATYPODIDAE.

This family of beetles appears structurally to be but distantly related to the true Scolytids. Yet in the type of gallery, which is bored to the very centre of large tree-trunks (and apparently never in the branches), in the habit of the larvae in not extending the tunnels, of the young adult beetle in escaping through the single hole made by the parent, and in the growth of ambrosia fungus and the staining of the plant-tissues, they resemble certain Scolytids of the genus *Xyleborus*. On the other hand, all records and observations force the conclusion that the male beetle bores first into the tree in which the broods are to be reared, and is afterwards joined by the female; after copulation the male appears to vacate the tunnel, leaving the female to complete the gallery, which is of extraordinary extension. Owing to difficulties of observation it has not been determined how many eggs are laid by the female, but it is probably in the region of a hundred. In most species the entrance tunnel (as extended by the female) runs horizontally straight into the heartwood, and in a trunk of six or eight inches diameter may pass through the centre and reach the cambium of the opposite side; a few horizontal branches are given off at intervals on each side, and from the latter vertical tunnels running up and down in the heartwood are constructed (Plate v, fig. 1). The larvae, though legless, can move rapidly

in these tunnels, and pupate in them, the eggs apparently being laid in the horizontal tunnels. The male beetles, produced in great numbers, become adult and emerge before the less numerous females, flying in swarms to the trees into which they will subsequently bore.

Though it has been firmly established that the host-trees chosen have in every case been in a very unhealthy condition, through the agency of fungi, an economic problem arose in connection with the cultivation of the rubber tree, *Hevea brasiliensis*, to which the attacks of these beetles are practically confined. For some years the practice of painting with tar, liquid fuel, or carbolineum the surfaces exposed by "tapping" had been resorted to, with a view to preventing the spread of canker upon those surfaces over which it is essential that the bark should regenerate evenly. It was reported from various districts that the painted surfaces had been attacked a few days afterwards by these beetles. Investigations showed conclusively that the beetles (nearly always males) had been attracted, not through any injury caused by the mixtures applied, but by patches of canker which had been dried off beneath them, and that though the insects had succeeded in boring through the layer of paint, in every case they had been drowned by the flow of latex from the tissues surrounding the wound which they had made. In cases where a considerable flow of latex takes place in the region of cankered bark it is not unusual to find 40 or 50 male beetles, with an occasional female, dead in the coagulated mass.

PLATYPODIDAE are definitely attracted to and make successful galleries in rubber, mango (*Mangifera indica*), cacao, and occasionally in the tea-plant, when these have been previously infected with the fungi *Diplodia*, *Coriticium* and *Poria*, but not in those infected with *Rosalinia*. They are rarely attracted to mechanical injuries, and do not come to light or to white objects, like many Scolytids.

The attack in the mango tree is attended by a profuse exudation of calcium oxalate from the bark, much resembling that caused by the entry of *Xyleborus compactus* into *Persea gratissima*.

Genus *Crossotarsus*.

Crossotarsus minax, Walk.

The largest Platypodid recorded from Ceylon, occurring commonly in the trunks of diseased rubber trees at low elevations, from July to December (one record relates to May); also found in a diseased mango tree and once recorded from a cacao tree. The entrance gallery runs straight towards the centre of the trunk (Plate v, fig. 1).

Crossotarsus venustus, Chap.

A single female from a gallery in a rubber tree, killed by fungus (Passara, October 1917).

Crossotarsus saundersi, Chap.

Eight males and two females recorded on 5th February 1918 in the trunk of a diseased mango tree from the Western Province. The entrance gallery is horizontal, but curved, and gives off vertical branches at intervals. At the end of these, clusters of chambers are made in which the larvae pupate (Plate v, fig. 2); these chambers appear to be constructed by the parent beetle, and not by the larvae. Many adult males were present in the galleries, but few females; they also contained numerous pupae and advanced larvae.

Genus *Platypus*.

Platypus solidus, Walk.

A very common insect, recorded in every month of the year except March, June and November, from sea-level to 2,000 feet. The female, however, is not often found except in galleries that have been vacated previously by the males. With a single

exception, where holes had been made in sawn timber of *Terminalia belerica*, all the records relate to the insects being found in the trunks of diseased rubber trees. The entrance tunnel curves sharply to one side on entering the sap-wood (Plate VI, fig. 1). The male beetles are found in great numbers drowned in masses of coagulated latex oozing from patches of cankered bark.

***Platypus lepidus*, Chap.**

Found but once in galleries made in the trunk of a rubber tree killed previously by the fungus *Diplodia*, in company with other PLATYPODIDAE (Nawalapitiya, August 1917, 2,000 feet). The extensive gallery runs straight into the wood horizontally, branching only on reaching the centre of the heart-wood; the vertical tunnels arising from the horizontal branches are comparatively short (Plate VI, fig. 2). One gallery contained 16 larvae.

***Platypus cupulatus*, Chap.**

A single female found with *Platypus lepidus*.

***Platypus uncinatus*, Blandford.**

Males were collected from a ringed toona tree (*Cedrela toona*) making short tunnels in the portion where the bark had been removed (Maskeliya, October 1915, 4,000 feet).

From notes left by the late Mr. A. Rutherford, it would appear that this species, which is not uncommon, made galleries in the trunks of tea-bushes previously attacked by the root fungus *Poria* in May 1913 (Haputala, 4,000 feet); some 60 or 70 bushes had been entered.

The following species have also been recorded from Ceylon: *P. cordatus*, Mot., *P. latifinis*, Walk., *P. luniger*, Mot., *P. rotundicauda*, Mot., and *P. excavatus*, Chap.

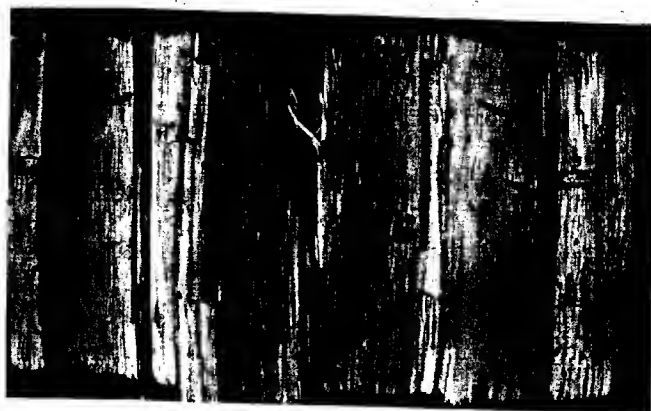


Fig. 1. Galleries of *Xyleborus fornicatus*, Eichh., and *X. parvulus*, Eichh., in a castor trunk (*Ricinus communis*). $\times \frac{1}{2}$

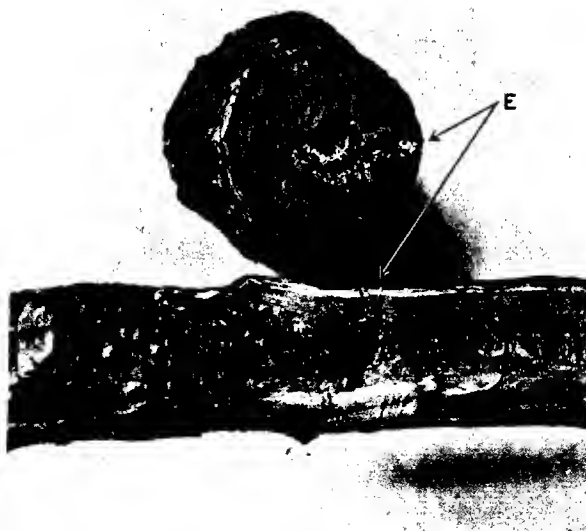


Fig. 2. Gallery of *X. compactus*, Eichh., in branch of avocado pear, the cross-section showing the dark stain due to a fungus (*Ceratostomella*) and a white exudation of calcium oxalate; E, entrance to gallery. $\times 2$



Fig. 1. Galleries of Xyleborus semipagus Eichh. in branches of Albizzia mollicana (above) and Hevea brasiliensis (below). x2.



Fig. 2. Branch of Albizzia mollicana showing a completed gallery of Xyleborus asperatus Blod. x2.



Fig. 3. The same, showing gallery in course of construction. x2.



Fig.1. Trunk of Hevea brasiliensis, previously injured by fire, showing entrance holes of Xyleborus interjectus. Blot. x 1/2.



Fig.2. The same, showing the galleries in cross-section x 1/2.



Fig.1. Section of trunk of *Hevea brasiliensis* showing gallery of *Xyleborus exiguus*, Walk., the clear portion being the chamber in which the larvæ congregate before pupation. x2.



Fig 2. Gallery of *X. discolor* in branch of honeysuckle (*Lonicera caprifolium*). x2



Fig 3 Gallery of *X. arquatus*, Samp., in a twig of camphor.

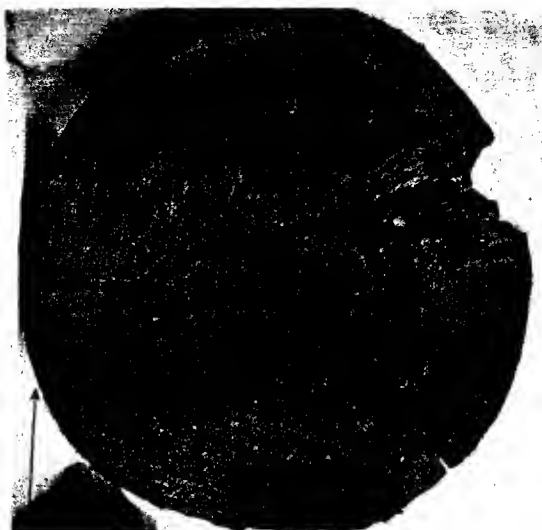


Fig.1. Cross-section of trunk of *Hevea brasiliensis* showing a gallery of *Crossotarsus minax*, Walk. x 9.



Fig.2. Longitudinal section of trunk of mango tree showing portion of a gallery and so-called "pupal chambers" of *Crossotarsus saundersi*, Chap. x 2.



Fig.1. Cross-section of trunk of Hevea brasiliensis showing a gallery of Platypus solidus, Walk. x3.

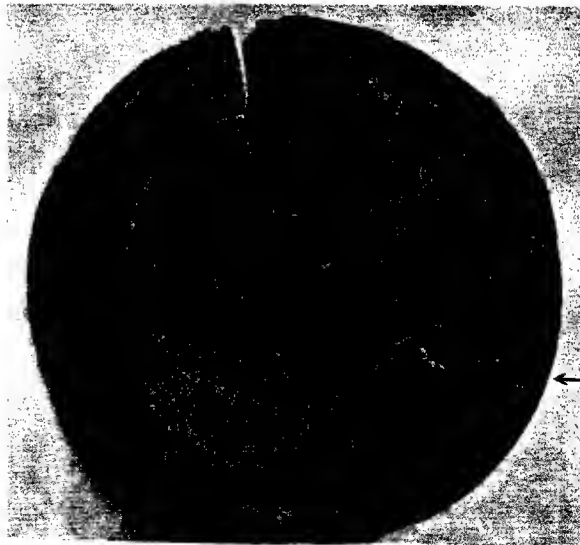


Fig.2. Cross-section of trunk of Hevea brasiliensis showing a gallery of Platypus lepidus, Chap. x3.

REPORT ON THE DISTRIBUTION OF TSETSE-FLIES IN THE NEIGHBOURHOOD OF ACCRA.

By J. W. S. MACFIE.

(PLATES VII & VIII, and MAP.)

The neighbourhood of Accra has generally been regarded as free from tsetse-flies. It has been known for a number of years, however, that occasional specimens of these insects were met with in the town of Accra itself, and this fact has given rise to both speculation and apprehension. In 1914, in the fifth part of his "Entomological Research in British West Africa," Dr. J. J. Simpson observed that "at distances varying from five to twelve miles from Accra both *G. palpalis* and *G. longipalpis* occur, and that these enter both railway carriages and motor wagons, and are thus transported into Accra," and although he considered it difficult to say if they would find suitable breeding grounds in or near the town, he regarded their presence as a distinct menace. More recently the same view has been expressed in connection with the importation into Accra of cattle heavily infected with trypanosomiasis. The desirability of determining the distribution of tsetse-flies in the neighbourhood was therefore clear, and as this had not previously been done, the present investigation was undertaken.

Physical Features.

From the hilly country north of Accra a range of low hills extends in a south-westerly direction to the coast. Between this range of hills and the sea lies a triangular area of more or less flat land, near the apex of which, situated actually on the coast, is the town of Accra. This tract of land may conveniently be referred to as the plain of Accra.

The greater part of this plain is bare and denuded, the vegetation consisting of grass sparsely dotted with trees. Here and there, however, small clumps of trees are found, and as the foot of the hills is approached they become more numerous and coalesce into larger clumps, patches of scrub sometimes of considerable size, and woods. On the slopes of the hills the vegetation is more dense and trees and thick bush are abundant. The whole area is exceptionally dry, most of the numerous rivers and streams marked on the map being, at the time of this investigation, at any rate, either unrecognisable as such, or represented merely by a few small, disconnected pools. The annual rainfall at Accra during the last 17 years (1905 to 1921) has averaged only 28.7 in. On the western side, however, there is more moisture, for here, on the far side of the hills, is the river Densu and its tributary the Nsaki.

The nature of the vegetation and the three zones into which it may be divided are illustrated by photographs taken along the Nsawam road. Plate vii, fig. 1, shows the dense, humid vegetation in the neighbourhood of the Nsaki; Plate viii the intermediate zone of patchy bush; and Plate vii, fig. 2, the arid plain extending thence to the coast.

The Distribution of the Tsetse-Flies.

At the time the investigation was started the occurrence of tsetse-flies had been recorded at very few places in the neighbourhood, the entomological card-index at the Medical Research Institute showing that they had been taken only at Oblogo, Weshiang, Domm, Ofako, Nsawam, Taiman, Aburi, Addadintan, and Dodowa, in addition to Accra itself. The attached map shows the distribution now known as the result of the recent investigation; the places at which tsetse-flies were found

being marked with a circle, those where they were sought in vain with a cross. The map is an outline traced from Africa, Sheet North B.30/R.11, 1st Edition, 1922, Provisional. Only the main features are marked on it, but further details, if required, can be ascertained by reference to the original. Three semi-circular lines have been added marking respectively the distances five, ten, and fifteen miles from Accra.

The investigation was conducted from Accra by means of a number of longer or shorter excursions which were extended to the west and the north until tsetse-flies were encountered. To the east, however, the limit of the tsetse-free area was not defined (as at the first we had intended it should be) because it was found to be so far distant as to be of no practical importance from the point of view of the investigation.

The map will to a large extent explain itself; but before passing on to its consideration there are one or two general facts which it is necessary to mention.

The investigation was carried out during a single month, beginning on the 19th of August, and ending on the 18th of September, 1922. Very little rain (0.74 in.) fell at Accra during this month, and it will be seen from the table given below, very little had fallen since the preceding June. The country was therefore very dry.

RAINFALL (IN INCHES) AT ACCRA, 1922.

Month.	Inches.	Month.	Inches.
January ..	0.22	June ..	6.11
February ..	0.27	July ..	0.16
March ..	1.40	August ..	0.71
April ..	2.53	September	0.06
May ..	5.56	to the	
		19th	

Tsetse-flies are sensitive insects, and both the species found in the neighbourhood of Accra require a certain degree of humidity. During the dry season they retreat towards the rivers and the areas where there is deep shade and moisture, and at the time the investigation was made this retreat had probably been in progress for some weeks. The distribution found, and recorded on the map, was therefore no doubt considerably more restricted than it would have been had the investigation been made during the rainy season. It is not surprising therefore that at a number of places where we failed to find tsetse-flies (such as Nglegon, Tetteogbu, Oblogo, Soutum, Aboba, Abokkobi, Oyamfa, Kweman, etc.) the inhabitants recognised and appeared to be familiar with these insects and stated that they occurred in their villages during the "rains." This retreat of the tsetse-flies perhaps also accounts for the fact that none was found during the investigation at certain places where they had been taken previously, namely, Accra, Oblogo, Domm, and Addadintan (marked ☉ on the map).

For several reasons the distribution shown on the map is probably more restricted than it should be. For example, the weather conditions although generally favourable were not always ideal, and it was not possible to visit every place at the hours of maximum activity of tsetse-flies. Moreover, in passing through a district it was not to be expected that we should observe or attract every fly in it, and thus many places where they were scanty, or had recently fed, or for some other reason were not obtrusive must have appeared to us to be tsetse-free.

Ten species of tsetse-flies are known to occur in the Gold Coast, but of these only two were found during the investigation, namely, *Glossina palpalis*, R.D., and *G. longipalpis*, Wied. It is not improbable that some of the others also occur in the

neighbourhood of Accra (*G. fusca*, Walk., and *G. pallicera*, Big., have been recorded from Aburi, and *G. fusca* was taken near Weshiang a few days after the investigation was ended), but *G. palpalis* and *G. longipalpis* are evidently the most important species. *G. palpalis* requires in its haunts deep shade and a high degree of moisture, and is found most commonly in forest along the banks of rivers. *G. longipalpis* also requires a considerable degree of both shade and moisture but less than *G. palpalis*, and is found in more open country.

It would be unwise to draw rigid conclusions from the species captured during this investigation at particular places because, as a rule, it was not possible to tarry anywhere longer than was necessary to secure one or two specimens. But in the aggregate the records are probably reliable, and they show clearly the difference of habitat of the two species. Thus *G. palpalis* was most abundant on the western side and was found only where the vegetation was dense and the humidity great (Plate vii, fig. 1), and did not spread at all on to the arid plain. *G. longipalpis*, on the other hand, was found in advance of *G. palpalis*, the area of distribution of the two species overlapping on the side of the rivers and the deepest shade, and that of *G. longipalpis* extending thence for a variable distance on to or towards the plain. *G. longipalpis*, indeed, was found most commonly in the intermediate zone where the scattered trees and bush of the plain begin to coalesce so as to form forest; it frequented the patches of bush and scrub at the foot of the hills, and especially the narrow paths or lanes through these patches, where it was repeatedly observed poised upon leaves and twigs by the wayside (Plate viii).

Passing now to the examination of the map, it may be pointed out in the first place that the distribution of tsetse-flies was found to correspond with the line of the hills. It will be remarked that they appear to be most abundant to the north-west where the road and railway pass to Nsawam. This may be due partly to the fact that the area was more thoroughly examined than some others, but undoubtedly it did appear that the flies preponderated here, a phenomenon which may be attributable to the proximity of the Nsaki and to the fact that the line of the hills is here broken, so that the tsetse-flies are able to advance more freely.

The hills, indeed, appeared to act as a barrier to the spread of the flies, sometimes stopping them altogether, sometimes allowing them to advance only through the passes. To the west of Accra, on the far side of the hills, *G. palpalis* was abundant at all the places examined on the river Densu and its tributary the Nsaki, and it is probable that they spread all along the courses of these streams. The hills in this region were crossed twice during the investigation, once from Nsakina and once from Joma, a small village to the north-west of Weshiang. On both these journeys *G. palpalis* was found in abundance down by the streams. From thence advancing uphill *G. longipalpis* was found extending nearly to the crest. At the crest no tsetse-flies were found, and none, or almost none, on the Accra side of the hills. From the foot of the hills to Accra the country was dry and very sparsely wooded, and here also no tsetse-flies were found. The influence of the hills as a check to the spread of the flies in this region was clear; it was due, in our opinion, not to the elevation, which indeed was very small, but to the change in the nature of the vegetation and the absence of streams and rivers.

From the hills the tsetse-flies spread on to the plain for a short distance. In this zone, which is a narrow one and is sometimes not clearly present at all, *G. longipalpis* is the predominant species, the shade and humidity being usually insufficient for *G. palpalis*. In the rainy season the conditions are no doubt more favourable, and reference has already been made to the evidence which exists of a wider distribution of tsetse-flies at that time of the year.

Beyond this zone lies the great plain of Accra, which is to all intents and purposes tsetse-free. There is no large game. On the whole the plain is very dry and very bare (Plate vii, fig. 2), and this is no doubt the chief reason why tsetse-flies do not

spread over it. Here and there deep shade may be found, here and there adequate moisture, but tsetse-flies are fastidious and require both, and practically nowhere on the plain is this demand satisfied. The fretting and flustering breeze which blows so often over the plain, and the presence of farms, are also probably adverse influences.

The Situation as regards Accra.

As regards the town of Accra itself, no tsetse-flies were taken within its bounds during the investigation. It is well known, however, that they do occasionally occur, and every year we capture a few (both *G. palpalis* and *G. longipalpis*) in the Medical Research Institute. Tsetse-flies are attracted by moving vehicles and are often transported from place to place in them. It is generally supposed, therefore, that the few specimens which occur in Accra are stray individuals which have been introduced in this way by motor lorries, railway trains, etc. This seems likely to be a correct explanation, and is to some extent supported by the fact that *G. palpalis* appears to occur as frequently as *G. longipalpis*.

No evidence was obtained during the investigation that such stray flies had established themselves in Accra, and no situations were found where they would be likely to do so. It is true that Accra from being a dusty desert is developing into a garden city, and that the shade now available is more favourable than it used to be, but the town is still exceptionally dry, and there is certainly no immediate danger of its becoming a tsetse haunt. If additional proof is required that tsetse-flies have not yet established themselves in Accra, it may be found in the fact that horses, dogs, and other domestic animals abound and do not suffer from trypanosomiasis, notwithstanding the fact that cattle heavily infected with parasites are constantly being introduced into the town.

Accra, moreover, is well protected from tsetse-flies by its situation, being surrounded on the land side by a plain rendered unsuitable for their habitation by its dryness, lack of shade, and fretting breeze. A note should be added here on the influence of farming. Cultivation is probably the most effective barrier that can be set up against the spread of tsetse-flies. Again and again during this investigation we failed to find tsetse-flies in villages surrounded by tsetse-infested country, and we were convinced that this was due to the fact that they were more or less cut off from the surrounding bush or forest by a belt of farms. We were also no less impressed during our tramps all over the district by the almost trifling area of the great plain of Accra that is cultivated.

There are four main roads leading out of Accra which may be regarded as possible lines of invasion by tsetse-flies, namely the Weshiang railway line, the Nsawam road and railway, the Dodowa road with its branch towards Aburi, and the Labadi road.

Along the Weshiang railway line tsetse-flies were first encountered at Weshiang, but they were found a little to the north of Oblogo, and at other seasons they have been taken actually at Oblogo. In this direction, therefore, tsetse-flies occur within about seven miles of Accra. The nature of the intervening country, however, renders it highly improbable that they could spread thence by natural means, although it is quite likely that occasional specimens may accompany passengers travelling by the trains.

Along the Nsawam road tsetse-flies were first encountered about ten miles from Accra, and a little further on they were abundant. In the rainy season they probably spread a few miles nearer, but beyond that much of the intervening country is inhospitable to such insects, and we would judge that Domm (about seven miles from Accra), where Simpson records having taken a specimen of *G. palpalis* in a railway carriage, must be the limit of their natural spread in this direction, if indeed this record was not itself a chance one. They also no doubt occasionally travel involuntarily by trains and motor cars which they have boarded.

Along the Dodowa and Aburi roads no tsetse-flies were found until the foot of the hills was almost reached, and much of the intervening country appeared to be quite unsuitable for their sheltering. Along the Dodowa road indeed, no tsetse-flies were found actually on the road-side up to the 21st milestone, although they were taken a little to the left up against the hills. Tsetse-flies, however, are abundant at Dodowa (25 miles), so that it may be assumed that they reached the road somewhere between that town and the 21st milestone, but it was not considered necessary to define the spot exactly, as it was of no practical importance.* In the rainy season the flies no doubt spread more widely from the hills and thus reach the road at points nearer to Accra. Simpson, for example, found *G. longipalpis* at Addadintan (11½ miles), and Dr. M. W. Fraser, who is well acquainted with tsetse-flies, tells me that on one occasion he was attacked by one of these insects when out shooting a little to the north-west of Gwantanang (? near Aboba, 10-11 miles). Along these roads flies which have boarded motor vehicles may occasionally be carried into Accra.

Along the Labadi road, as far at any rate as the Mokwi lagoon, a little beyond Nungwa, no tsetse-flies were found, and so far as the eye could see the country appeared to be unsuitable for their accommodation.

Nowhere on these roads, then, were tsetse-flies found nearer than seven miles from Accra, and in all directions the town was separated from the tsetse-infested areas by a wide inhospitable zone across which the flies do not, and probably could not, pass voluntarily.

Summary.

The results of the investigation may be summarised as follows: Two species of *Glossina* were encountered in the neighbourhood of Accra, namely, *G. palpalis*, R.-D., and *G. longipalpis*, Wied. They were found all along the range of hills to the west and north of the Accra plain, and extending thence a little way on to the plain, *G. longipalpis* spreading rather farther than *G. palpalis*. The greater part of the plain was found to be free from tsetse-flies and unsuitable for them. In the town of Accra itself no tsetse-flies were found, and although it is well known that occasional specimens reach it (probably being transported thither by motor vehicles and railway trains), no evidence was obtained that they had established themselves there or would be able to do so under existing conditions.

* On 8th October, shortly after the investigation was ended, *G. palpalis* was taken on the Dodowa road at 23½ miles from Accra. This record, and one or two others made at the same time between the 21st milestone and Dodowa, have been added to the map.

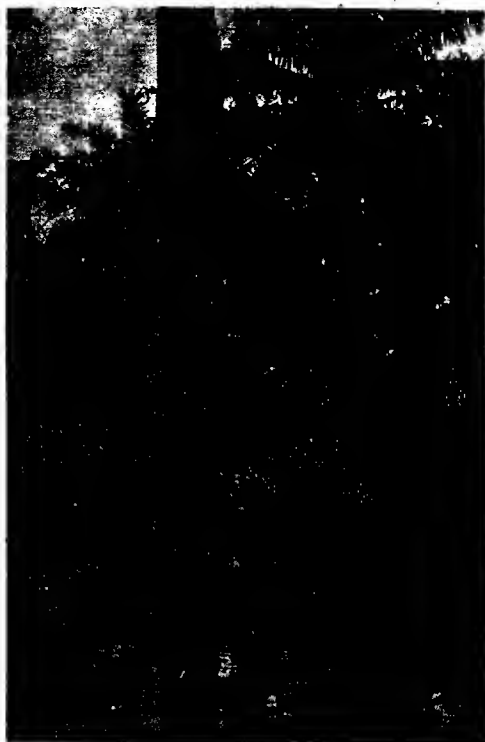


Fig 1. Roadside scene near Pokoase; Glossina palpalis taken here



Fig 2 Part of the arid plain of Accra, unsuitable as a haunt for tsetse-flies.



Fig 1. Lane through the patchy "bush" typical of the haunts of Glossina longipalpis.



Fig 2. General view of the country near Ofako showing the patchy "bush".

NOTES ON LOCUSTS OF ECONOMIC IMPORTANCE, WITH SOME NEW DATA ON THE PERIODICITY OF LOCUST INVASION.

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The present paper is a part of the results of my revisional work on the group CYRTACANTHACRINI, which includes all the swarming locusts except *Locusta migratoria* (L.), the latter having formed the subject of a previous paper.* The revision itself, being of a purely systematic character and dealing also with a large number of species of no economic interest, is being published elsewhere,† but I thought it might be useful to economic entomologists to give here the principal conclusions arrived at concerning the species of known agricultural importance, especially because this presents an opportunity of discussing some important points in the bionomics of swarming locusts which would be out of place in the revision itself.

The generic classification of the group has been in a most unsatisfactory state, and I have had to establish a number of new genera, fully described in the revision, where also an illustrated key to the genera is given. This involved the necessity of alterations in the previously used names of almost all economic locusts, while a critical study of the original descriptions, as well as of the majority of existing types, enabled me to establish their correct synonymy; this latter is also given in full in the revision, while here only some of the more important synonyms are included, merely in order to reduce the number of names now in use for the same species.

The paper deals exclusively with the Old World locusts, although I could not avoid discussing one of the South American species closely related to an Old World one.

Schistocerca gregaria (Forsk.) (fig. 1).

Synonyms: *Acridium peregrinum*, Oliv.; *Schistocerca tatarica*, Kirby, Syn. Cat. Orth. (not *Gryllus Locusta tataricus*, L.).

Systematic Notes.—This insect is known to economic entomologists mostly under the name of *Schistocerca peregrina*, Ol. (for which Kirby incorrectly substituted *S. tatarica*), but the name *S. gregaria*, Forsk., has priority.

One of the interesting points in connection with this species is that it is the only Old World representative of the genus, which is widely distributed and represented by a large number of species in South America, penetrating partly also into the Southern United States. One of the South American species, *S. paranensis*, Burm., so closely resembles *S. gregaria* that some authors have considered them to be conspecific and have suggested that *S. gregaria* is of South American origin and migrated across the Atlantic ocean to Africa, where it has found suitable conditions for existence. This suggestion induced me to undertake a comparative study of these two species,‡ and my definite conclusion is that *S. paranensis* is undoubtedly distinct from *S. gregaria*, as has been stated by some authors, and especially by Arribalzaga (Physis, iv, no. 16, 1918, pp. 49–79). The characters separating these two insects may be briefly summed up as follows:—

1. Face in *paranensis* more reclinate, but perfectly vertical in *gregaria*. Frontal ridge in *gregaria* distinctly constricted at the fastigium, widened above the ocellum,

* A revision of the genus *Locusta*, L. (= *Pachytylus*, Fieb.), with a new theory as to the periodicity and migrations of locusts.—Bull. Ent. Res., xii, 1921, pp. 135–163.

† Ann. Mag. Nat. Hist., beginning April 1923.

‡ I am greatly obliged to the authorities of the United States National Museum and, to Dr. A. N. Caudell for the loan of an extensive series of *S. paranensis* for this purpose.

constricted below it and parallel-sided elsewhere; in *paranensis* not constricted at the fastigium, only slightly and gradually widened downwards, constricted below the ocellum and with the margins distinctly divergent towards the clypeus.

2. Fastigium of vertex in *paranensis* more distinctly sloping, broader and shorter, than in *gregaria*.

3. Pronotum of *gregaria* very strongly constricted in the prozona, decidedly selliform, with the metazona much broader than the prozona, and also broader than long; while in *paranensis* it is simply conical, scarcely constricted, with the metazona only slightly broader than the prozona and not broader than long.

4. Anal field of the elytra in *paranensis* narrower than in *gregaria*.

5. Hind femora in *paranensis* thicker and shorter than in *gregaria*.

6. Mesosternal lobes in *paranensis* with the hind inner angles acute and attenuate, while in *gregaria* the angles are practically straight; the mesosternal interspace, accordingly, is strongly narrowed posteriorly, almost cordiform, in *paranensis*, and only slightly narrowed, with the margins straight, in *gregaria*.

7. Metasternal lobes contiguous in males and narrowly separated in females of *paranensis*, while in *gregaria* they are distinctly separated in males and broadly so in females.

8. Male cerci of *paranensis* more or less emarginate apically; those of *gregaria* obliquely truncate.

9. Male subgenital plate with the lobes acutangular in *gregaria*, and broader, distinctly rounded apically, in *paranensis*.

10. The most important and constant difference in the coloration is the presence in *paranensis* of a more or less distinct pale, dark-edged, fairly broad stripe along the pronotum, which is never present in the common swarming form of *gregaria* (for description of an aberrant, probably non-swarming form, see below); again, the lateral lobes of the pronotum are quite uniformly coloured in *gregaria* (in the swarming form) and with more or less distinct dark and pale fasciae in *paranensis*; the hind tibiae are in the latter red or reddish, and yellow in *gregaria*, except in sexually immature specimens, which are reddish all over; the hind femora of *paranensis* are unicolorous, but with numerous dark dots along the outer carinae, while in *gregaria* they have, as a rule (but not always), dark bands on the upper side, and no dots on the carinae.

It is not easy to decide whether all these characters are sufficient to justify the specific separation of *gregaria* from *paranensis*, as the extent of variability of the latter still remains unstudied, and some of the specimens before me now show that it is not inconsiderable, and, what is especially noteworthy, the variation may go in the direction of *gregaria*, while the pronotum becomes more strongly constricted, and the frontal ridge and mesosternal interspace show a distinct likeness to those of *gregaria*.

On the other hand, the material of *gregaria* studied shows that the above-mentioned characters of that insect are also not always constant. Amongst the variations found there is one which deserves special attention, because I am convinced that it represents a solitary living phase* of the species. This form agrees perfectly well with the description of *Acridium flaviventre*, Burm. (Handb. Entom., ii, p. 631, no. 11, 1838) and I call it, accordingly, *S. gregaria* ph. *flaviventris*, Burm. Its description is as follows (see also fig. 1 B, C):—

Differs from the typical (swarming) phase in the pronotum being much more rugose, and with scattered round callous tubercles (especially in metazona), less widened in metazona, which is about as long as broad (broader than long in *gregaria*) with the hind angle almost straight; median keel well developed also in the prozona,

* The term introduced by me in the paper on *Locusta* (l.c.).

deeply and broadly cut by the sulci; the upper surface distinctly darkened, with a narrow pale stripe along the median keel; the lateral lobes in the metazona darker than in the prozona, which bears a fairly distinct longitudinal stripe along the middle and another broader one along the lower margin which is pale; mesosternal interspace strongly narrowed posteriorly, with the sides somewhat convex; the hind angles of the mesosternal lobes somewhat attenuate, though less so than in *paranensis*.

This remarkable form is known to me by specimens from the following localities: Kenhardt district, Cape Province, 27.xi.1917, 1 ♀ (the above redescription is based on this particular specimen); Northern Ceres district, Cape Province, 15.xi.1917, 1 ♀; Namaqualand, ix.1917, 3 ♂♂; Rietfontein, Gordania, Cape Province, 17.iv.1917, 1 ♀; St. Vincent, Cape Verde Islands, 2 ♀♀; Ascension Island, 1 ♀; Red Sea, W. shore of Port Sudan, desert north of railway, 29.ii.1912, 1 ♀ (G. B. Longstaff); Ain Guettara, north of In-Salah, Central N. Sahara, 12-14.iv.1912, 1 ♀ (E. Hartert); Thebes, Egypt, 1 ♀; Chaharbar, Persian Gulf, 7.ii.1917, 1 ♀; Naxos, Greece, 16.iv.1862, 1 ♀.*

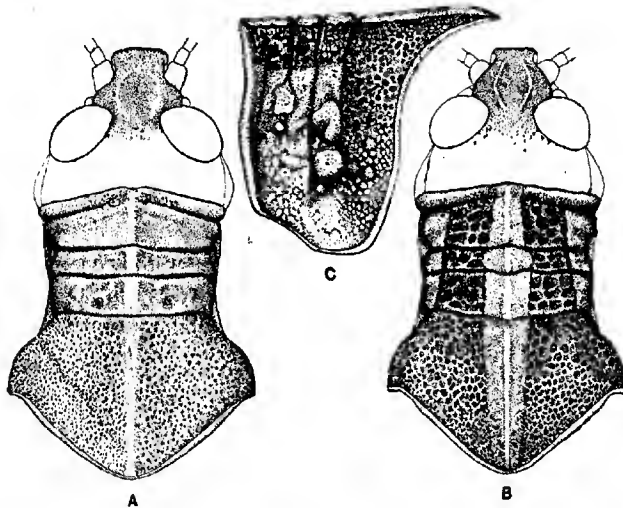


Fig. 1. *Schistocerca gregaria* (Forsk.): A, phase *gregaria*; B, C, phase *flaviventris*, Burm. $\times 4$.

This form shows an extremely interesting tendency of *S. gregaria* to vary in the direction of *S. paranensis*, displaying at the same time certain characters of its own.

The distinctions of *flaviventris* from the common swarming phase (which should be called ph. *gregaria*) are very striking, but there occur some clearly transitional forms between them; thus, a male in the British Museum, from Zanzibar, agrees perfectly in the shape of the pronotum with the typical *gregaria*, while its coloration is that of *flaviventris*, and the sculpture is intermediate between the two forms; another specimen, a female from Hadramaut, Arabia, has the pronotum shaped and sculptured as in *flaviventris*, but quite uniformly coloured. The possibility of regarding *flaviventris* as a geographical race (subspecies) of *gregaria* is out of the question, since

* There is in the British Museum one more male of this form, labelled "Matuku, 24.7.74," brought home by the "Challenger" Expedition, but the occurrence of the species in that locality (Fiji Islands) seems to me highly improbable, and this is probably a case of mislabelling.

the two forms seem to have practically the same distribution. These considerations lead to the only possible conclusion, namely, that *gregaria* and *flaviventris* represent two different phases of one dimorphic species, exactly as is the case with *Locusta migratoria* and *Locustana pardalina* (Uvarov, l.c.). There is no doubt that *gregaria* is the swarming phase of the species, as the specimens actually taken from swarms invariably belong to it, but there is also no doubt in my mind that *flaviventris* represents the solitary phase. This suggestion is based, primarily, on the comparative scarcity of *flaviventris* in collections, where it is almost always represented by single specimens from each particular locality, never bearing a label that they have been taken from a swarm, while labels of that kind are not unusual on specimens of *gregaria*. It is, however, not only on these, partly negative, proofs that my interpretation of *flaviventris* is founded, as I have before me the definite evidence of Dr. E. Hartert relating to a female of *flaviventris* taken by him in the Sahara, and stating that "there were no swarms of locusts in Northern Sahara in 1912 and the specimen I got at Ain Guettara was not out of a swarm but single." This interesting observation confirms my point of view in a most decisive manner, though direct observations on the transformation of one phase into another are needed. I hope, however, that these lines will attract the attention of field entomologists to the problem.

Geographical Distribution.—*S. gregaria* is an essentially African species, extending also into south-western Asia (as far north as Transcaspia*) and as far east as Kashmir, whence there is one specimen in the British Museum, unfortunately without more precise locality), and into Southern Europe (Corfu, Naxos, Portugal), but its distribution in Africa, and especially its permanent breeding regions, are yet very inadequately known. It is well known as a swarming locust in Algeria, Tunisia, Morocco, Egypt (in the latter only occasionally), Sudan, East Africa and Senegal, while it seems to be absent from the whole belt of tropical forests, but reappears again in South Africa, whence both phases are known to me by specimens (Johannesburg, Capetown and other localities in the Cape Province whence ph. *flaviventris* is recorded; see above), as well as from the literature (numerous records are given by H. Karny in Zool. Anthropol. Ergebn. Forschungsreise in W. und Centr. Südafrika, etc., iv, Lief. 1, 1910, p. 65), though the records of its occurrence there as a swarming locust are lacking, which, however, may be due simply to its confusion with the superficially similar *Nomadacris septemfasciata*, Serv. (see below). Karny, in the paper quoted above, expressed the opinion that the South African area of distribution of the species is not connected with the North African one, and he asserts even that the latter does not extend farther southwards than Senegal and the Red Sea. The erroneous nature of this assertion is shown by the well-known work of Vosseler (Die Wanderheuschrecken in Usambara, Ber. über Land- und Forstwirtschaft in D.-Ostafrika, ii, 1905, Heft 6), which was published five years before Karny's paper, as well as by numerous East and West African localities given by La Baume (Die Afrikanischen Wanderheuschrecken. Beih. z. Tropenpflanzer, Bd. xi, no. 2, 1910, p. 115). It is true that there are yet no records from Portuguese East Africa, Nyasaland and Rhodesia, but this may be attributed partly to the confusion of swarms of this species with those of *N. septemfasciata*, and partly to specimens of the solitary phase being, probably, very wary and difficult to catch.†

Quite interesting are the records of this species from some of the Atlantic Islands—Cape Verde, Grand Canary and Ascension (British Museum)—which can only be explained as a result of migrations of swarms from the African mainland. That migrations of this species may be and are extensive enough to enable it to reach even an island as remote as Ascension cannot be doubted, since there are in the British Museum two specimens of the ph. *gregaria* taken as far as 500 miles

* An evidently stray specimen has been recorded by me from that country.—Horae Soc. Entom. Ross., xl, no. 3, 1912, p. 31.

† I am inclined to attribute to this latter cause the comparative scarcity of the solitary phase in collections.

from land, and Scudder has recorded a swarm that came on board a ship in lat. $25^{\circ} 28'$ north, long $41^{\circ} 33'$ west, *i.e.*, about midway between Africa and America, with the nearest point of land 1,200 miles off (Psyche, ii, 1883, p. 124). This latter fact caused Scudder to explain the first appearance of the species in the Old World as a result of direct migration across the ocean from South America, since he thought that the species occurred in the latter country as well. In my opinion, however, the presence of *S. gregaria* in the New World has never been positively proved, as old records are unreliable and apply to *S. paranensis* (and possibly some other American species), while some specimens in the South American material from the U.S. National Museum, which are similar in general appearance to *gregaria*, are in fact different from it exactly in the characters separating the latter from *paranensis*. As for true *gregaria*, the British Museum collection contains two specimens labelled as being of South American origin; one of them is the type of *Acridium sellatum*, Walker, and reputed to be brought by Charles Darwin from Montevideo, but is not labelled in Darwin's own hand, as all his other insects are; another specimen is labelled "Berbice," but neither collector nor the date of collection are known, which makes this record also quite unreliable. I am inclined to think, therefore, that there is no true *gregaria* in South America, but this can be definitely settled only by American entomologists working on the spot. This opinion does not directly contradict Scudder's conclusion, which is also generally accepted, that *S. gregaria* is of South American origin, since it is the only Old World representative of a genus consisting of many New World species.

Bionomics.—I am not going to dwell here on the individual life-history of *S. gregaria*, which is already comparatively well known owing to the investigations of Künckel d'Herculais* and of Vosseler,† though many important points, especially those concerning the physiology, still require elucidation. My intention is only to discuss briefly some points of the species-life of this locust in connection with its swarming habits.

In the first place I should like to draw attention to Vosseler's conclusion (*l.c.*, p. 339) that the migration either of larval or of adult swarms has nothing whatever to do with the want of food, which agrees perfectly with what I have stated for *L. migratoria*. Another often repeated explanation of the causes of migration of adult swarms—that they are looking for new suitable breeding-grounds—is also most emphatically denied by Vosseler for *S. gregaria*, again in complete accordance with my observations on *L. migratoria*. Künckel d'Herculais (*l.c.*) has already observed, and Vosseler has studied more thoroughly, the extremely interesting colour changes in the individuals forming migratory swarms; these changes are in *S. gregaria* far more pronounced than in *L. migratoria*, but it is highly probable that they are due to the same causes, and I believe that they are in direct physiological connection with the processes of the maturation of the sexual products, and of the development and reduction of the fat-body; further researches in this direction are, however, necessary.

Unfortunately, the annual life-cycle of *S. gregaria* is yet very incompletely known, and practically nothing at all has ever been done to study its permanent breeding-grounds; in fact, it is not known even whether there are any definite conditions necessary for its permanent breeding. This makes a study of the periodicity of this species impossible on the basis of existing records, but the occurrence of two different phases of the species suggests a promising line of investigation; it is obvious that the clue to the solution of the problem of periodicity lies in a thorough study of the conditions of existence of both phases, and of the changes in those conditions necessary to produce a transformation of one phase into the other. This will necessitate investigations not only during the years of mass invasions, but also, if not much

* Invasions des acridiens, vulgo sauterelles, en Algérie. Algier. 1893-1905.

† Die Wanderheuschrecken in Usambara im Jahre 1903-1904, zugleich ein Beitrag zu ihrer Biologie.—Ber. Land- u. Forstwirt. in D.-O.-Afrika, ii, 6, 1905.

more thoroughly, in the years of minimum occurrence, when the solitary phase is more likely to be found. Observations of this kind have been conducted by German entomologists in East Africa, but have not been published in full; a short note by Morstatt,* however, states definitely that the periodicity of locusts in German East Africa was due not to invasions from outside, as is too often suggested without any serious evidence, but to periodical increased multiplication of local insects, living usually scattered on dry grass-lands (solitary phase?). This author is inclined to attribute the periodical increases in the number of locusts, leading to the formation of swarms (as a result of transformation into the swarming phase?) to abnormally dry years; future students of *S. gregaria* should pay attention to the influence of moisture and temperature on the development of this locust.

Anacridium aegyptium (L.).

Synonyms: *Acridium aegyptium*, L.; *Orthacanthacris aegyptia*, L.

The economic importance of this well-known Mediterranean species is almost negligible, as it never swarms and occurs always in single, scattered specimens, but it is an occasional pest of leaves of cotton plants in Turkestan, Transcaucasia, the Punjab and Egypt; more serious injury has been recorded to young tobacco plants in Dalmatia and Italy.†

Valanga nigricornis melanocornis (Serv.).

Synonyms: *Acridium melanocorne*, Serv.; *Acridium consanguineum*, Serv.; *Cyrtacanthacris melanocornis*, auct.; *Orthacanthacris melanocornis*, auct.

Systematic Notes.—My study of this genus (*l.c.*), which ranges from Australia to Indo-Malaya, showed that some of the species are widely spread over the numerous islands and represented by a corresponding number of geographical races. Thus, the Javanese *Acridium melanocorne* is only a subspecies of *A. nigricorne*, Burm., which occurs in Malacca.

Bionomics.—A detailed account of this insect has been published by Roepke,‡ who studied it in Java, where it is a serious occasional pest of various wild and cultivated plants, particularly of *Castilloa*, bread-fruit, *Ficus*, *Hevea*, coconut palms and maize. It is not a swarming species, since it does not display any social and migratory instincts even when it appears in large numbers.

It is not impossible that other subspecies of *V. nigricornis*, Burm., may prove to be of economic importance in other parts of Indo-Malaya.

Patanga succincta (L.).

Synonyms: *Acridium succinctum*, L.; *Cyrtacanthacris succincta*, L.; *Orthacanthacris succincta*, L.; *Acridium assectator*, F.-W., etc.

Systematic Notes.—This insect, known to Indian entomologists as the "Bombay locust," is readily recognisable by the straight, laterally compressed prosternal tubercle, the rose-coloured base of the wings, and by the pale elytra with but few grey marks.

Geographical Distribution.—The species is distributed all over southern and south-eastern Asia and the Malay Archipelago (Sumatra, Borneo, Nias), but its exact range is as yet very inadequately known. According to Bainbrigg Fletcher§ it "occurs throughout the plains of India and Ceylon," but a more exact definition of its area is wanting.

* Die Ursachen der Heuschreckenplagen in Ostafrika.-Kosmos, 1921, No. 3.

† Sorauer, Handbuch der Pflanzenkrankheiten, iii, p. 182.

‡ Dr. W. Roepke, Sprinkhanenplagen.—Teysmannia, xxvi, 1915, pp. 115-124; 337-358; 758-790.

§ Proc. Third Entom. Meeting at Pusa, i, 1920, p. 310.

Bionomics.—As an occasionally swarming locust the species is known only from the western parts of the Indian peninsula (Bombay Presidency), where a large invasion took place in 1903–1904. The investigations made on that occasion by Maxwell-Lefroy* still represent our only source of information on the bionomics of the species during the swarming period, but the data given by that author are so complete and detailed that little more is to be desired. I do not intend to repeat here the results of his investigations, which showed that the life-cycle of the swarms of this species is much more complicated than of other locusts, but should like to draw attention to certain facts supporting my theory of locust migrations. The outstanding feature of the bionomics of this species is that it takes as much as about nine months for an adult to reach sexual maturity. This prolonged sexual development is in accord with the extended period of migration, which is divided by Lefroy in two periods, separated by a resting period of about three months; the parallelism between the behaviour of swarms and the development of the sexual products, air-sacs and the fat-body is also noticed by Lefroy, thus corroborating my idea that the migration of locust swarms is due primarily to internal physiological processes.

The reason for the periodicity of *P. succincta* is quite obscure, and the cause of mass outbreaks, which seem to occur much more seldom and less regularly than in other locusts, cannot at present even be guessed. Information as to whether the species occurs in two different phases is also lacking, but I am inclined to think that there is no regular swarming phase, the individuals from swarms not differing appreciably from the solitary ones in their external morphology, and possessing also comparatively feebly developed social instincts.

***Austracris guttulosa* (Walk.).**

Synonym: *Cyrtacanthacris guttulosa*, Walk.

This species and *A. basalis*, Walk. (= *A. plagiata*, Walk.) have been recorded by Jarvis† as being classed as sugar-cane pests in the Brisbane collection of economic insects in the Agricultural Department, but he has not yet been able to confirm this view, and the specific identification also is not reliable.

***Austracris basalis* (Walk.).**

Synonyms: *Cyrtacanthacris basalis*, Walk.; *C. plagiata*, Walk.

The short description which Jarvis (*l.c.*) gives of the insect which he calls *Cyrtacanthacris* (?) *proxima* applies to *A. basalis* better than to any other known species, and I believe it to be the same.‡

***Nomadacris septemfasciata* (Serv.).**

Synonyms: *Acridium septemfasciatum*, Serv.; *Cyrtacanthacris fascifera*, Walk.; *C. purpurifera*, Walk.; *C. subsellata*, Walk.; *Acridium sanctae-mariae*, Finot; *A. coangustatum*, Luc.

Systematic Notes.—The outstanding feature of this insect, which (if it be examined with due attention) makes a mistake in its identification quite impossible, is the reticulation of the basal half of the elytra, which is finer and denser than in any other locust of that size; the cellules between the veinlets are correspondingly minute

* The Bombay Locust (*Acridium succinctum*, Linn.).—Mem. Dept. Agr. India, Entom. Ser., i, 1, 1906.

† Notes on Insects damaging Sugar-cane in Queensland.—Bureau Sug. Expt. Stat., Div. Entom., Bull. No. 3, 1916, p. 22.

‡ There should be other true swarming locusts in Australia, but exact records are lacking.

and also distinctly elongated, not rounded or angular as in other locusts. Oblique transverse dark fasciae (about seven in number) on the elytra and the almost obliterated median keel of the pronotum furnish further distinguishing characters. The rose coloration of the hind wings, which caused this species to be called "Red Locust"* in South Africa, is not a constant character, and it is very likely that it may change during the individual life (probably in connection with the development of the sexual products).

The species is very constant in its structural characters, save in one—the shape of the pronotum, and in that respect two different forms of the species may be distinguished. In one form the pronotum is comparatively shorter and has a distinct constriction before its middle; this is the more common (and also the typical) form, and all the specimens taken from swarms, seen by me, belong here. Another form, described by Lucas as *Acridium coangustatum* from Réunion and later on by Finot as *A. sanctae-mariae* from Madagascar, and known to me also by a few examples from different localities in Africa, differs from the typical form in the pronotum being relatively more elongate and without a constriction, but simply narrowed anteriorly. As this type of difference is characteristic for the swarming and solitary phases of some other locusts in which the phases are actually known (*Locusta migratoria*, *Locustana pardalina*, *Schistocerca gregaria*), I venture to suggest that *coangustata* is but a solitary phase of *septemfasciata*; this suggestion, of course, needs confirmation, but it may be useful to draw the attention of future students of this species to it.

Geographical Distribution.—The exact distribution of this locust is not yet sufficiently known. It inhabits South Africa, extending in the west as far as the lower Congo (Luki, Leopoldville, Kinchassa), while in the east the most northern localities known to me are: Lake No, at the junction of Bahr-el-Gazal and Bahr-el-Djebel in the Sudan, and Zegi-Tsana, Abyssinia. The species occurs also in Madagascar, Réunion and the Comoro Islands; it seems that from the islands only the ph. *coangustata* is known. Further localities for the latter are: Luki, Mayumbe, on the lower Congo; Valley of Muza, basin of lower Zambezi; Luangwa Valley, North-Eastern Rhodesia; Uganda; Mount Chirinda, Southern Rhodesia; Pretoria.

Bionomics.—Although the species is known as an occasionally very serious pest of different crops, our knowledge of its bionomics is very unsatisfactory. Thus, its breeding conditions have never been studied, and even the annual life-cycle is not definitely established. It seems, however, that in the latter respect *N. septemfasciata* belongs to the same group as *Patanga succincta*, i.e., it passes a very long period (winter months) of its adult life in a sexually immature state, which is the cause of a correspondingly long period of migrations. At the same time, it also does not swarm so regularly as *Schistocerca gregaria* or *Locustana pardalina*, and in this respect again agrees with *Patanga succincta*. Thorough studies of this species, prolonged over several years, covering not only mass invasions but the periods of minimum occurrence as well, when the solitary phase may be expected, should yield results of practical importance.

***Acanthaeris ruficornis fulva* (Sjöst.).**

Synonyms: *Acridium citrinum*, auct., nec Serv.; *Acridium fulvum* (Sjöst.).

I believe that this is the insect recorded by Zacher† under the name *Acridium lineatum*, St., as an occasional pest of tobacco in Nyasaland, since *lineata* is the South-West African race of the species, and *fulva* the East African one.

* I am inclined to think that this name might in some cases lead to the confusion of this species with *Schistocerca gregaria*, as this latter insect is red all over when migrating in sexually immature swarms. Thus it is not unlikely that some records of the "Red Locust" should be referred to *S. gregaria*.

† Tropenpflanzer, xx, 1917, no. 4, p. 169.

***Cyrtacanthacris tatarica* (L.).**

Synonyms: *Acridium ranaceum*, Stoll; *A. aeruginosum*, Burm. et auct. (nec Stoll); (not *Schistocerca tatarica*, Kirby, see above).

The species enjoys an unusually wide distribution, being common all over Africa (south of the Sahara), Madagascar, Seychelles, Ceylon and India, reaching as far east as Siam.

According to Bainbrigge Fletcher* *C. tatarica* "occurs throughout the plains of India on almost all crops, but is usually found in small numbers only. It is a minor pest of cotton and other crops." There are no records of this species being injurious in Africa.

***Chondracris rosea* (De Geer).**

Synonyms; *Gryllus flavicornis*, F.; *Acridium flavicorne*, F.; *A. melanocorne*, Lefroy† (nec Serv.).

This large, solitary-living species, easily recognisable by its uniformly green coloration and rose wings, has been recorded by van Deventer‡ amongst other minor and occasional pests of sugar-cane in the Dutch East Indies, where it occurs as the race *Ch. rosea brunneri*, Uvar.

* Proc. Third Entom. Meeting at Pusa, i, 1920, p. 310.

† Mem. Dept. Agric. India, i, no. 1, p. 53, pl. xii, fig. 3; Indian Insect Life, p. 74, fig. 19.

‡ De dierlijke vijanden van het suikerriet en hunne parasieten, 1912, p. 279.

NOTES ON SOME AFRICAN CERATOPOGONINAE.

By A. INGRAM and J. W. S. MACFIE.

Through the kindness of Dr. G. A. K. Marshall, of the Imperial Bureau of Entomology, and Mr. F. W. Edwards, of the British Museum, we have been enabled to examine the two small but interesting collections of African CERATOPOGONINAE which form the basis of this paper. We have attempted to determine or describe the majority of the specimens, but those belonging to the genus *Forcipomyia* we hope to deal with at some future time. Several species were represented by single or but few specimens, some of them damaged; further material is therefore much to be desired not only to confirm and complete the descriptions given, but also to determine the ranges of variation.

We regret that we have been compelled in most cases to study the collections from a regional point of view, and that we have had to suggest some new specific names which may eventually prove to be synonyms. There can be little doubt that many species which in different parts of the world have received different names are actually identical. But in the CERATOPOGONINAE specific differences are often most distinct in structures which are frequently omitted from descriptions, or are sometimes only discernible at magnifications greater than those used by some authors, or by the employment of a technique which will render the insects transparent and will counteract the distortions produced by drying; and as for these reasons many descriptions are insufficiently detailed to admit of exact comparison being made, we consider it would be unjustifiable to assume identity without actual examination of specimens from different localities.

We have pleasure in acknowledging our indebtedness to Mr. A. J. Engel Terzi for the skill and the care with which he has prepared the figures for this paper. The unit of measurement referred to in the text is 3.6μ . The types and cotypes of the new species described are in the British Museum collection.

***Jenkinsia accraensis*, sp. n.**

Length of body* (one female), 2.2 mm.; length of wing, 2.4 mm.; greatest breadth of wing, 1.1 mm.

Head darkish brown, pruinose; occiput sparsely clothed with brown hairs. Eyes bare, widely separated above. Clypeus brown, sparsely clothed with brown hairs. Proboscis brown, well chitinated. Palpi brown, short; first segment quite small, the four other segments measuring in the single female examined eleven, thirteen, eight, and ten units respectively; the third segment not inflated, without a sensory pit, the fifth segment slightly dilated at its distal end. *Mouth-parts* well chitinated; mandibles bearing about seven strong teeth. *Antennae* missing from the specimen with the exception of the first five segments on one side. First segment brown, bearing three small hairs. Torus brown, bearing a few short hairs. Segments 4 and 5 brown cylindrical or slightly barrel-shaped, nearly twice as long as broad. *Thorax* darkish brown, pruinose, and paler brown posteriorly; narrowed anteriorly and prolonged dorsally over the head in a manner similar to that found in the genus *Macroptilum*, without a median spine on the anterior margin; sparsely clothed with brown hairs. Pleurae brown. Scutellum darkish brown, bearing six bristles, three

* In all cases this measurement is taken from the anterior margin of the thorax to the tip of the abdomen of specimens mounted in pure carbolic acid.

on each side. Post-scutellum darkish brown. *Wings* (fig. 1) unadorned, the anterior veins brownish; long, voluminous, broadest in the proximal quarter, tapering to a rounded tip. Wing surface densely clothed with rather large microtrichia, but without macrotrichia; fringe short. Costa feebly developed distally. Cross-vein situated near the middle of the wing. First vein short, moderately developed; third vein arched, joining the costa at the tip of the wing. Two cells, the second about four times as long as the first. Bifurcation of the fourth vein some distance proximal to the cross-vein, that of the fifth vein still nearer to the base of the wing. Halteres with large, dark brown knobs which are densely clothed with microtrichia and bear also a few larger hairs. *Legs* brown, the femora, the apices of the hind tibiae, and the last three tarsal segments rather darker than the rest. Hind legs not unusually long. Femora not swollen, unarmed, slightly longer than the tibiae on all the legs. Tibiae armed apically with a large, pale brown spine on the fore legs, and with a pair of dark spines on the middle legs; slightly longer than the first tarsal segment on all the legs. First tarsal segment about three times as long as the second on the fore legs, four times on the middle legs, and twice on the hind legs; armed with

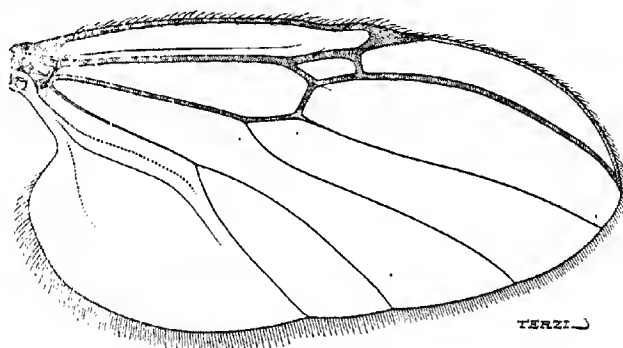


Fig. 1. *Jenkinsia accraensis*, sp. n., wing of ♀.

numerous ventral and a pair of apical spines on the middle legs, and bearing a row of bulbous hairs on the hind legs. Third tarsal segment almost cordiform on the fore and middle legs, slightly longer or bell-shaped on the hind legs. Fourth large and transversely elongated on the fore legs, short and broad, but not so broad, on the middle and hind legs. Fifth fusiform on the fore and hind legs (missing from the middle legs in our specimen), and armed with six dark spines or batonnets, three on each side. Claws on the fore legs stout, equal, rather more than half the length of the fifth tarsal segment, each bearing a short, blunt, basal barb; on the hind legs similar to those on the fore legs but rather longer. Claws of middle legs missing from our specimen. Empodium absent or rudimentary. *Abdomen* brown, the terminal segments paler than the rest, very sparsely clothed with hairs, and bearing on the ventral aspect of the eighth segment on each side of the middle line a patch of long bristles. Spermathecae three, highly chitinised, oval, the two lateral ones subequal, about $75\ \mu$ by $55\ \mu$, the middle one larger, about $85\ \mu$ by $75\ \mu$; the commencement of the duct chitinised for only a short distance, about $4\ \mu$.

GOLD COAST: Accra, 1922, 1 ♀ (Dr. A. Ingram).

So far as can be determined from Kieffer's description this insect appears to resemble *Jenkinsia setosipennis*, K., but to differ from it in a number of characters, such as the length of the third vein of the wing, the armature of spines on the fifth tarsal segments, and the claws of the hind legs.

***Macroptilium nigeriae*, sp. n.**

Length of body (one female), 6.0 mm.; length of wing, 6.6 mm.; greatest breadth of wing, 1.7 mm.

Head (fig. 2, *a*) very dark brown, almost black, small, depressed vertically between the eyes, the occiput sparsely clothed with black hairs. Eyes bare, very widely separated above (by nearly 0.2 mm.). Clypeus dark brown, very sparsely clothed with hairs. Proboscis dark brown, short, highly chitinated. Palpi (fig. 3, *a*) darkish brown, short, tapering towards the apex; first segment small, second, fourth, and

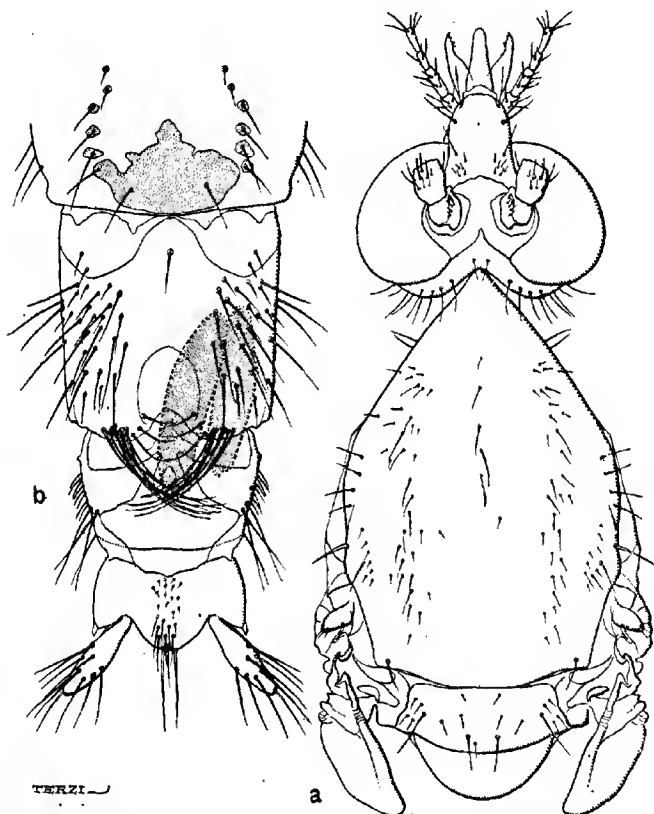


Fig. 2. *Macroptilium nigeriae*, sp. n., ♀: *a*, dorsal view of head and thorax (head displaced); *b*, ventral view of posterior extremity of abdomen.

fifth subequal, third about one-third as long again, not inflated, without a sensory pit, but bearing sensory hairs on the inner aspect of its distal half, fifth scarcely swollen at its end. *Mouth-parts* well chitinated; mandibles dark-coloured at their ends, highly chitinated, bearing three strong and a number of small teeth. *Antennae* entirely very dark brown, thickly clothed with short, spine-like, dark brown hairs. First segment relatively well developed, bearing only a few small hairs. Torus small, bearing a number of short and also stout, spine-like hairs. Third segment

cylindrical, more than twice as long as the fourth. Segments 4 to 10 cylindrical, subequal, nearly two and a half times as long as broad. Segments 11 to 15 elongated, subequal, the eleventh being the shortest and the fifteenth the longest, about eight or nine times as long as broad, the last segment tapering distally and ending in a blunt point. *Thorax* (fig. 2, *a*) uniformly very dark brown, almost black, prolonged anteriorly into a peak which extends over the head, very sparsely clothed with short black hairs. *Pleurae* very dark brown, almost black. On each side of the thorax behind the wing is a large flange-like cuticular expansion. *Scutellum* uniformly very dark brown, bearing two centro-marginal and two lateral bristles and a few short hairs. *Post-scutellum* very dark brown, almost black. *Wings* (fig. 3, *b*) long, shaped similarly to those of *Macropitulum nudum*, more or less infuscated and quite a deep brown colour at the base and along the anterior margin. Veins dark. Venation

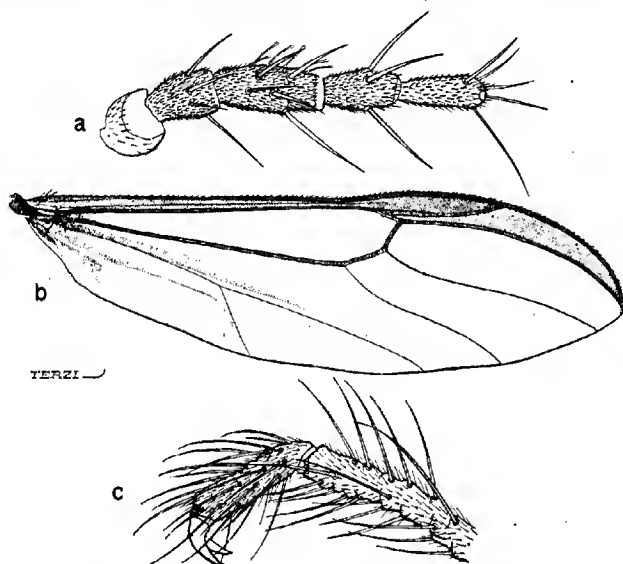


Fig. 3. *Macropitulum nigeriae*, sp. n., ♀: *a*, palp; *b*, wing; *c*, termination of hind leg.

as shown in the figure; anterior cross-vein situated beyond the middle of the wing, the third vein and the costa joining practically at the tip of the wing. There is no fringe, the posterior margin of the wing being bordered by a narrow costa. Wing surface densely clothed with minute microtrichia, but without macrotrichia. Halteres with dark brown stems and almost black knobs, bearing on each side a few minute hairs. *Legs* brown. Fore and middle legs relatively short, especially the former; femora and tibiae a reddish brown, first two tarsal segments pale brown and last three infuscated; femora not swollen, unarmed; first tarsal segment about four times as long as the second, third bell-shaped, fourth cordiform, fifth as long as the third and fourth together, not swollen, armed ventrally with two (usually) short, stout, black spines. Hind legs extremely long, especially the tarsi; femora and tibiae reddish brown, not swollen, unarmed, measuring in one instance 2.3 mm. and 2.2 mm. respectively; first four tarsal segments pale brown, apices of the first three and the distal half of the fourth infuscated, all cylindrical, very slender, and greatly elongated, measuring in one instance about 5.4 mm., 1.9 mm., 1.1 mm., and 0.7 mm. respectively,

the last tarsal segment entirely dark brown, short (about 0.12 mm.), not swollen, unarmed. Claws (fig. 3, c) on all the legs equal, stout, short, about one third the length of the fifth tarsal segments, simple. Empodium rudimentary. Abdomen (fig. 2, b) very dark brown, tapering distally, the last three segments differentiated and more completely and strongly chitinated than the others, sparsely clothed with small hairs, the eighth segment bearing ventrally on each side of the middle line a tuft of long bristles. Spermathecae two, highly chitinated, sausage-shaped, unequal, measuring in the single female examined about 300 μ by 80 μ and 245 μ by 80 μ respectively, practically no part of the duct is chitinated.

NIGERIA (NORTHERN PROVINCES) : Ilorin, 16.vii.1912, 2 ♀♀ (Dr. J. W. S. Macfie).

This species differs most notably from *Macroptilum nudum*, Becker, the type species of the genus which was collected at Cairo, in the extreme length of the hind tarsi and the absence of the fringe from the wings.

***Macroptilum aethiopicum*, sp. n.**

Length of body (one female), 4.3 mm.; length of wing, 6.3 mm.; greatest breadth of wing, 1.5 mm.

Resembling in general the last species, but not so dark. Head very dark brown, almost black; occiput sparsely clothed with rather long dark hairs. Eyes bare, very widely separated above. Clypeus brown, sparsely clothed with hairs. Proboscis brown, short, highly chitinated. Palpi brown, the terminal segment rather darker than the others, short, much as in *Macroptilum nigeriae*; first segment small, second and fourth subequal, third and fifth rather longer, subequal, the third without a

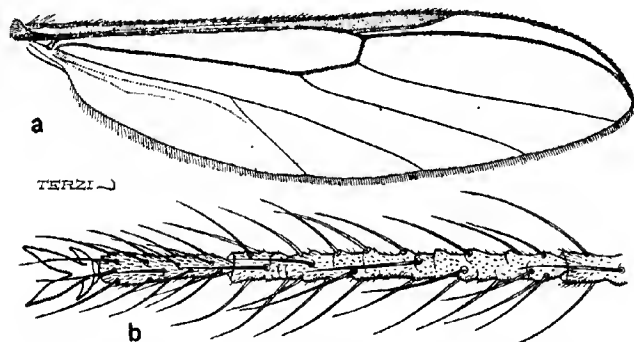


Fig. 4. *Macroptilum aethiopicum*, sp. n., ♀: a, wing; b, termination of hind leg.

sensory pit. Antennae entirely very dark brown, thickly clothed with short dark hairs. First segment relatively rather large, bearing a few rather long hairs. Torus small, much as in *M. nigeriae*. Third segment cylindrical, about twice as long as the second. Segments 4 to 10 as in *M. nigeriae*, subequal, about three times as long as broad. Segments 11 to 13 elongated, subequal, about five or six times as long as broad. Segments 14 and 15 missing. Thorax brown, with broad darker brown longitudinal stripes, two admedian on the anterior third and two lateral more posteriorly; shape as in *M. nigeriae*, sparsely clothed with dark hairs. Pleurae brown. Scutellum brown, bearing numerous small hairs and five or six bristles which are feebly developed. Post-scutellum very dark brown, paler brown basally, sparsely clothed with very small hairs. Wings (fig. 4, a) long, less pointed than those of *M. nigeriae*, and hardly at all infuscated excepting at the anterior margin from the base to the end of the first

vein. Venation much as in *M. nigeriae*, but cross-vein situated nearer to the middle of the wing, and the third vein not reaching quite so near to the tip. Fringe present. Wing surface densely clothed with microtrichia (which are larger than those of *M. nigeriae*), but without macrotrichia. Halteres with pale brown stems and white knobs. Legs brown, with infuscated knees. Fore legs short; first and second tarsal segments infuscated at their apices, third and fourth infuscated all over, fifth entirely dark brown; femora not appreciably swollen, unarmed; first tarsal segment shorter than the tibiae but a little more than twice as long as the second, third bell-shaped, fourth cordiform, fifth a little longer than the third and fourth together, not swollen, armed ventrally with three to five short black spines. Middle legs longer; femora not swollen, unarmed; tibiae longer than the first tarsal segment, bearing a dark apical spine; first tarsal segment long, infuscated at its apex, bearing numerous black spines, second infuscated at its apex, bearing a pair of black apical spines, third infuscated excepting at its extreme base, rather more elongated than on the fore legs, fourth dark brown, cordiform, fifth as long as the third and fourth together, dark brown, bearing two pairs of short black spines. Hind legs greatly elongated as in *M. nigeriae*; femora and tibiae brown, darker at the knees and at the distal ends of the tibiae, tarsal segments pale brown, the first three infuscated only at their extreme apices, the fourth over its distal third, and the fifth entirely dark brown and unarmed; in one instance the measurements of the femur, tibia, and tarsal segments were approximately 2.2 mm., 2.06 mm., 4.5 mm., 1.4 mm., 0.8 mm., 0.4 mm., 0.17 mm. respectively. Claws (fig. 4, b) on all the legs small, stout, equal, with basal barbs, those on the fore and middle legs about half the length of the fifth tarsal segments, those on the hind legs smaller, about three eighths the length. Abdomen dark brown, eighth and ninth segments white dorsally, sparsely clothed with dark hairs. Tufts of hairs on the ventral aspect of the eighth segment as in *M. nigeriae*. Spermathecae as in *M. nigeriae*.

ZULULAND: Mfongosi, iii.1917, 1 ♀ (W. E. Jones).

We are indebted to Dr. L. Peringuey, Cape Town, for the opportunity of examining this specimen.

Lasiohelea lefanui, Carter.

In the collections placed at our disposal were numerous specimens (all females) from Eastern Africa which, at first glance, appeared to be referable to two or three distinct but closely allied species of *Lasiohelea*. On more detailed examination, however, it was found that numerous intermediate forms occurred, and on comparing the Eastern African specimens with others from Nigeria and the Gold Coast which we have in our possession we were convinced that, notwithstanding their sometimes striking dissimilarities, they all belonged to a single variable species, namely, to that species for which Carter (1916) proposed the name *Forcipomyia lefanui*. We have also examined four specimens of the South American *Lasiohelea* (*Centrorhynchus*) *stylifer*, named by Dr. Lutz, which are in the collection of the Liverpool School of Tropical Medicine, and have been unable to detect any differences by which they could be distinguished from the African species. We have not yet had an opportunity of examining the other species referable to the genus, namely, *L. velox*, Winn., *L. pilosipennis*, Kieff., and *L. stimulans*, de Meijere, but Edwards (1922) states that the latter species, of which he had examined specimens from Sumatra, Ceylon, and Queensland, is "practically identical in structure with *L. stylifer*," and in this case the name *L. stimulans*, which has priority, would include the South American species (*L. stylifer*), the West African species (*L. lefanui*), and also the species from Eastern Africa.

With regard to the European species, *L. velox* and *L. pilosipennis*, it may be noted that Edwards considers it "quite probable that the two are identical," and that Keiffer's description of the latter, while being insufficiently detailed to admit of an

exact comparison, does not disagree with that of the African species. It is therefore possible that on further investigation, in which the examination of males would be important, it may be found that all these insects belong to a single, widely distributed, species which is variable and tends to the formation of local races.

Length of body (females) 1.2 to 1.5 mm.; length of wing, 0.8 to 1.2 mm. greatest breadth of wing, 0.4 to 0.5 mm.

A dark brown midge varying in colour from chestnut or dark amber-coloured to almost black; with paler, more yellowish brown legs, and unspotted wings. *Head* dark brown; occiput well clothed with rather long hairs. Eyes bare; contiguous above, the facets separated only by a narrow line. Clypeus dark brown, bearing a few hairs. Proboscis dark brown, about as long as the head. Palpi dark or darkish brown, with rather long hairs: first segment quite small; second about half the length of the third or a little longer; third as long as or longer than the fourth and fifth together, strongly inflated in the middle, especially on the inner side, furnished with a very large sensory pit with a wide opening; fourth and fifth small, subequal, usually about twice as long as broad but sometimes shorter, as broad as long, occasionally confluent; the fifth only slightly, or not at all, dilated at its end. The orifice of the sense organ in the third segment of the palp is not situated at the apex of a tubercle, as described and figured by Carter, the appearance in his specimen, which we have been privileged to examine, being due apparently to the evagination of the sensory pit. *Mouth-parts* well chitinated; mandibles furnished on their inner distal margins with numerous (about twenty) small teeth. *Antennae* brown or dark brown, first segment and torus darker than the flagellum; hairs moderately long. First segment relatively large, bearing several strong hairs. Torus rather small, subglobular, bearing a few small hairs. Third segment small, only slightly larger than the fourth, subspherical or broader than long, with a short basal stalk. Segments 4 to 10 short and broad, gradually elongating and narrowing, the length of the fourth usually decidedly less than the breadth (about three-quarters) but sometimes almost equal to it, that of the tenth from just over one to one and a third times the breadth. Segments 11 to 14 elongated, tapering slightly from the base, subequal, three to four times as long as broad; segment 15 more cylindrical, slightly longer, about five times as long as broad, ending in a stylet or nipple-like process two or three units long. The combined lengths of segments 3 to 10 less than those of segments 11 to 15; the ratio, however, is somewhat variable, being in the specimens examined by us as follows: West Africa (Nigeria and Gold Coast) 0.7, Zanzibar 0.6, Kenya 0.5, Uganda 0.4, and South America (*L. stylifer*) 0.6 to 1. In addition to hairs, all the flagellum segments bear short blunt spines, and the basal ones (three to ten) long slender spines also. *Thorax* uniformly dark brown, sometimes glossy, sometimes pruinose, well clothed with shortish dark brown hairs and longer, stronger ones laterally and posteriorly. *Pleurac* dark brown. *Scutellum* dark brown, bearing a transverse row of eight long bristles and about ten small hairs. In this species, as in many others, the number of hairs and bristles is slightly variable. *Post-scutellum* dark brown. *Wings* as figured by Carter in the case of *L. lefannii*. Third vein joining the costa at about two-thirds of the length of the wing from the base. Immediately beyond this junction the thickening of the anterior margin of the wing is interrupted for a short space. Wing surface densely clothed with both microtrichia and macrotrichia. Halteres varying greatly in colour, the knobs containing a white pigment, which is usually more or less obscured by infuscation, so that their colour ranges from almost pure white, cream-coloured, yellowish or pale brown to dark brown. All gradations were found in the collections at our disposal. *Legs* yellowish brown to darkish brown, almost uniformly coloured, rather densely hairy. Femora not swollen and unarmed, tibiae not swollen. First tarsal segment on the fore and hind legs about two and a half times as long as the second, on the middle legs slightly shorter, about twice as long as the second; the other tarsal segments on all the legs cylindrical, successively decreasing in length. Claws rather

stout, equal, simple, strongly curved, about half the length of the fifth tarsal segment. Empodium about as long as the claws, hairy. *Abdomen* dark brown, but not so dark as the thorax (except in specimens that have sucked blood), the venter rather paler than the dorsum; well clothed with dark brown hairs, which are longest laterally and apically. Spermatheca (fig. 5) single, subspherical to oval, the basal portion not at all or but feebly chitinised, so that the distal portion (which is highly chitinised) appears as a dome-shaped structure with a wide opening; the duct not chitinised at its commencement. The size of the spermatheca varies considerably, for example, in specimens from Zanzibar it measured about 58μ by 47μ (the chitinised part 50μ by 47μ , and the diameter of the basal opening about 29μ); in others, from Uganda, 86μ by 75μ (the chitinised part 75μ by 75μ , and the diameter of the basal opening about 43μ). Various intermediate sizes were found in materials from other sources.

GOLD COAST: Salaga, 11.vi.1911 (*Dr. G. E. H. Lefanu*). NIGERIA (NORTHERN PROVINCES): Ilorin, Old Residency, 29.viii.1921, several females taken biting at 1 p.m. (*Dr. J. R. C. Stephens*); Tegna, 31.viii.1910, 1 ♀ (*Dr. J. J. Simpson*); Mariga, 1.ix.1910, 1 ♀ (*Dr. J. J. Simpson*). UGANDA: Kasala, Mpumu (forest), viii.1910, 5 ♀♀ (*Capt. A. D. Fraser*); Kisala, xii.1910, 3 ♀♀ (*Dr. van Someren*). KENYA: Southern foot and slopes of Mount Elgon, 5,100-5,800 ft., 8-13.vi.1911, 10 ♀♀ (*Dr. S. A. Neave*); East foot of Mount Elgon, 6,000 ft., 2.iii.1912, 5 ♀♀ (*R. B. Woosnam*). NYASALAND: Central Angoniland (no date), 74 ♀♀ (*Sir David Bruce*). ZANZIBAR: Prison Island, 1.iv.1912 and 2.xii.1918, 51 ♀♀ (*Dr. W. M. Aders*).

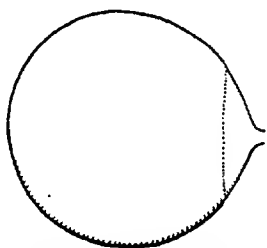


Fig. 5. *Lasiohelea lefanui*, Carter, spermatheca of ♀.

***Atrichopogon cellatum*, sp. n.**

Length of body (one male), 1.7 mm.; length of wing, 1.6 mm.; greatest breadth of wing, 0.4 mm.

Head dark brown, occiput clothed with dark brown hairs. Eyes bare; contiguous above. Clypeus dark brown. Proboscis dark brown, well developed, highly chitinised. Palpi dark brown, slender; second and fourth segments subequal, third about half as long again as the second, feebly inflated in the middle, furnished with a small sensory pit, fifth slightly longer than the fourth, not dilated at its end. *Antennae* dark brown, torus darker than the flagellum; plumes large, dark brown. Segments 4 to 11 progressively decreasing in size and elongating slightly, the length ranging from just over one to nearly one and a third times the breadth. Segment 12 nearly three times as long as broad. Segments 13 to 15 elongated, about six or seven times as long as broad, the thirteenth the longest and the fifteenth tapering distally and ending in a stylet about four units long. *Thorax* almost uniformly dark brown but with markings as in *A. hirsutipennis*. *Pleurae* dark brown. *Scutellum* rather dark brown but paler than the rest of the thorax, not yellowish as in *A. hirsutipennis*, bearing two lateral and two centro-marginal bristles and a few (about six)

small hairs. Post-scutellum dark brown. *Wings* (fig. 6; a) clear, unadorned. Wing surface, as usual, densely clothed with microtrichia, but macrotrichia confined to the tip of the wing above the upper ramus of the fourth vein, and a few distally between the rami of the fourth vein. First radial cell narrow, slit-like. Fork of the fifth vein at about the level of the base of the second radial cell. Halteres with white knobs. *Legs* almost uniformly brown. First tarsal segment on all the legs nearly three times as long as the second; fourth short, almost bell-shaped. Claws

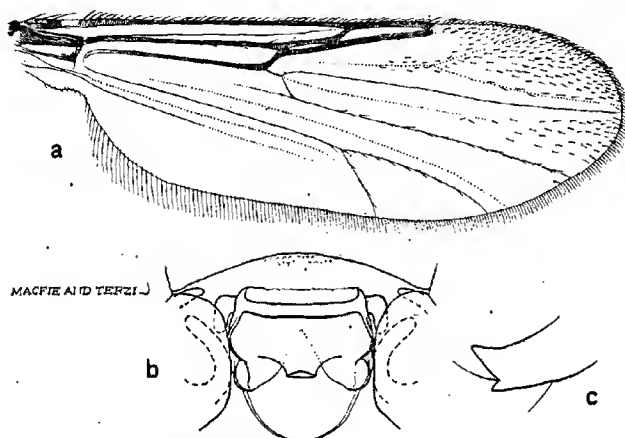


Fig. 6. *Atrichopogon celibatum*, sp. n., ♂: a, wing; b, diagram of median structures of hypopygium, ventral view; c, extremity of clasper.

equal, strongly curved, about half the length of the fifth tarsal segment, with bifid tips. Empodium as long as the claws, hairy. *Abdomen* dark brown. *Hypopygium* (fig. 6, b): ninth segment with tergite as in *A. melanimum*; sternite only very slightly excavated posteriorly, bearing numerous hairs. Forceps well developed; side-pieces of the usual form, dorsal basal root-like processes large and curved; claspers with bifid ends (fig. 6, c). *Aedoeagus* in ventral view as shown in the diagram, with large lateral basal processes which project dorsally.

SOUTH AFRICA: Mossel Bay, Cape Province, vii.1921, 1 ♂ (R. E. Turner).

It is not improbable that this insect is the male of one of the African species that have already been described, of which only the females are known, but as it is not possible at present to correlate it with certainty, we propose for it the name *Atrichopogon celibatum*.

***Atrichopogon hirsutipennis*, sp. n.**

Length of body (one female), 1.7 mm.; length of wing, 1.5 mm.; greatest breadth of wing, 0.6 mm.

Head very dark brown, occiput clothed with dark brown hairs. Eyes bare; contiguous above, the facets separated only by a narrow line. Clypeus dark brown. Proboscis dark brown, well developed, highly chitinated. Palpi dark brown; second, fourth, and fifth segments subequal, third nearly twice the length of the fourth, inflated about the middle, narrowed distally, and furnished with a large sensory pit, fifth not at all dilated at its end. *Antennae* dark brown, hairs short and scanty. First segment relatively large and hairy. Torus very dark brown, bearing a few small hairs. Segments 4 to 10 subspherical to oval, the fourth being actually

subspherical and the tenth nearly once and a third as long as broad. Segments 11 to 15 cylindrical, elongated, from about three to four times as long as broad, the last segment being the longest and ending in a stylet about four units long. *Thorax* almost uniformly dark brown, but with a narrow, pale brown, admedian antero-posterior stripe on each side which terminates just before the lateral border of the scutellum in a small, elongated white mark. *Pleurae* dark brown. *Scutellum* yellowish, slightly infuscated laterally, bearing two lateral and two centro-marginal bristles and about twenty small hairs. *Post-scutellum* very dark brown. *Wings* (fig. 7) as in *A. xanthoaspidium* but much more hairy, almost the whole surface, with the exception of the radial areas, being densely clothed with macrotrichia in addition to the usual microtrichia. *Halteres* with white knobs. *Legs* brown, terminal segments somewhat infuscated. First tarsal segments on all the legs nearly three times as long as the second; fourth cylindrical. *Claws* equal, strongly curved, about half the length of the fifth tarsal segment, each bearing a minute subapical tooth. *Empodium* at least as long as the claws, hairy. *Abdomen* dark brown, but not so dark as the thorax, and the venter rather paler proximally; rather sparsely clothed with dark brown hairs. *Spermathecae* two, highly chitinated, bearing minute clear areas, which, however, are indistinct, oval to pyriform, unequal, measuring in the single female examined about $80\ \mu$ by $47\ \mu$ and $110\ \mu$ by $65\ \mu$ respectively; the duct chitinated at its commencement for a short distance, about $8\ \mu$, and merging insensibly with the narrowed base of the spermatheca.

SOUTH AFRICA: Mossel Bay, Cape Province, vii.1921, 1 ♀ (R. E. Turner).

This insect closely resembles *A. xanthoaspidium* in some respects, but may readily be distinguished from that species by the hairiness of the wings.

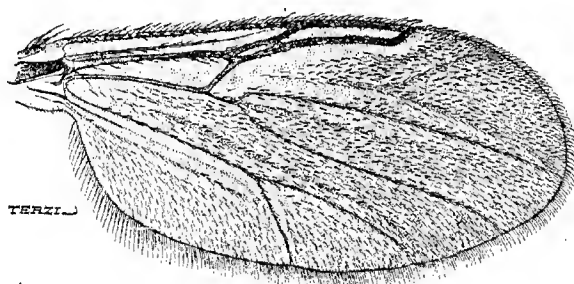


Fig. 7. *Atrichopogon hirsutipennis*, sp. n., wing of ♀.

***Atrichopogon melanimum*, sp. n.**

Length of body (one male), 1.8 mm.; length of wing, 1.4 mm.; greatest breadth of wing, 0.4 mm.

Head very dark brown, occiput well clothed with dark hairs. *Eyes* pubescent all over; narrowly separated above. *Clypeus* dark brown. *Proboscis* dark brown, well chitinated. *Palpi* (fig. 8, a) dark brown, second, fourth and fifth segments subequal, third about one-third longer, only slightly inflated in the middle, furnished with a large sensory pit, fifth slightly dilated at its end. *Antennae* uniformly dark brown, with large dark brown plumes. *Segments* 4 to 11 gradually decreasing in size and becoming more elongated anteriorly, the fourth subglobular, the eleventh slightly longer than broad. The twelfth segment similar to the eleventh but more elongated anteriorly, nearly three times as long as broad. *Segments* 13 to 15 cylindrical, elongated, from nearly six to about three times as long as broad, the thirteenth the

longest, the fifteenth ending in a small nipple-like process about two units long. *Thorax* very dark brown, clothed with short dark hairs. *Pleurae* very dark brown. *Scutellum* very dark brown, bearing two lateral and two centro-marginal bristles and about ten small hairs, two of which, situated near the middle of the posterior margin, are rather larger than the others. *Post-scutellum* very dark brown. *Wings* (fig. 8, *b*) clear, unadorned; veins pale brown. Wing surface densely clothed with microtrichia, but without macrotrichia. Venation much as in *A. xanthoaspidium*, but first radial cell larger and the petiole of the fourth vein shorter. Halteres with white knobs. *Legs* brown, terminal tarsal segments slightly infuscated. First tarsal segment on the fore and middle legs rather more than three times, on the hind legs slightly less

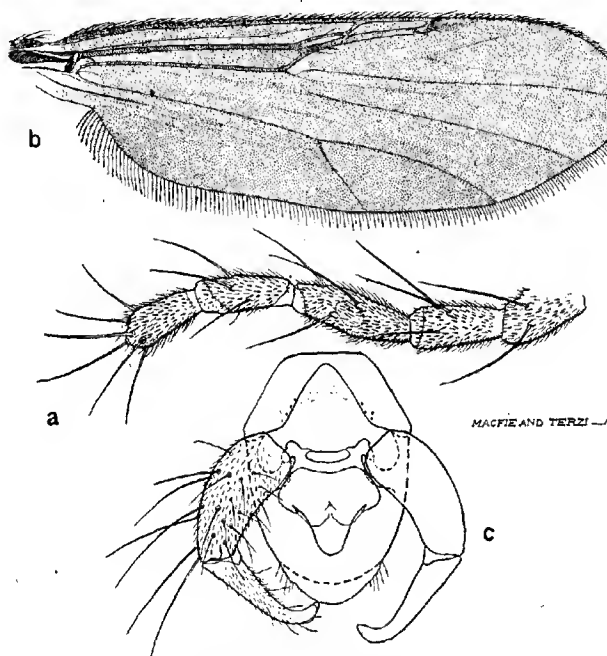


Fig. 8. *Atrichopogon melanimum*, sp. n., ♂: *a*, palp; *b*, wing; *c*, diagram of hypopygium, ventral view.

than three times the length of the second; fourth cylindrical; fifth slightly longer than the fourth. Claws equal, strongly curved, about half the length of the fifth tarsal segment, each with a bifid tip. Empodium long, at least as long as the claws, hairy. *Abdomen* dark brown, venter rather paler brown; sparsely clothed with short hairs. *Hypopygium* (fig. 8, *c*): ninth segment with tergite large, clothed with long hairs, the posterior margin rounded, with a membranous posterior extension, the lateral borders of which are chitinised; sternite very deeply notched in the middle line posteriorly, bearing on each side of the notch near the posterior margin a group of four or five small hairs, the membrane occupying the apex of the notch being covered with small spicules. Forceps: side-pieces of the usual form, hairy, the root-like basal processes very strong, curved; claspers densely chitinised at their ends, hairy. Aedoeagus similar to that of *A. kelainosoma*, I. & M.

SOUTH AFRICA: Mossel Bay, Cape Province, ii. 1922, 1 ♂ (*R. E. Turner*).

This species resembles *A. kelainosoma*, I. & M., but may be distinguished from it apparently by a number of characters, for example, by the greater hairiness of the eyes, the greater length of the terminal segments of the antenna and the spine on the fifteenth segment, the larger number of small hairs on the scutellum, the colour of the halteres, and the position of the fork of the fifth vein of the wing, which in *A. kelainosoma* is rather more distal, being situated at about the level of the distal end of the first radial cell, whereas in *A. melanimum* it is at about the level of the middle of this cell.

***Atrichopogon natalensis*, sp. n.**

Length of body (one female), 2.2 mm.; length of wing, 2.0 mm.; greatest breadth of wing, 0.7 mm.

Head dark brown, occiput rather densely clothed with dark hairs. Eyes pubescent, especially at their inner lateral margins; contiguous, separated by a narrow line only. Clypeus dark brown. Proboscis dark brown, well developed, densely chitinated. Palpi dark brown, second segment a little shorter than the third, third the longest, inflated, and furnished with a well-developed sensory pit, fourth and fifth subequal, about half the length of the third, fifth not dilated at its end. *Mouth-parts* highly chitinated; mandibles armed with about twenty-five very small teeth on the inner distal margin. *Antennae* uniformly dark brown, hairs short. First segment relatively

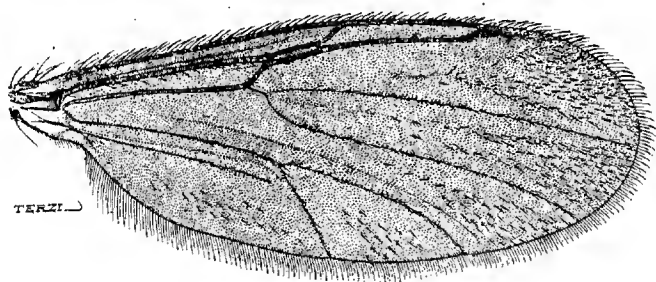


Fig. 9. *Atrichopogon natalensis*, sp. n., wing of ♀.

large, bearing a number of longish hairs. Segments 4 to 10 short and broad, their lengths increasing from a little less than to a little more than the breadths. Segments 11 to 15 elongated, cylindrical, subequal, about four times as long as broad, the last segment being, however, rather longer than the others and ending in a nipple-like process. *Thorax* dark brown, pruinose, clothed with dark hairs. *Pleurae* dark brown. *Scutellum* paler brown, bearing two lateral and four centro-marginal bristles and about a dozen small hairs. *Post-scutellum* dark brown. *Wings* (fig. 9) somewhat infuscated but without special adornment; veins brown. Wing surface densely clothed with rather large microtrichia and bearing also numerous macrotrichia, which are distributed as in *Atrichopogon xanthoaspidium*, C., I. & M., but are rather more numerous and extend further towards the base of the wing. Venation as in *A. xanthoaspidium* but first radial cell larger. Halteres with yellowish, almost white, knobs. *Legs* brown, the terminal tarsal segments somewhat infuscated, unarmed with spines, moderately hairy. First tarsal segment on all the legs three times as long as the second, second, third, and fourth cylindrical, successively decreasing in length, fifth slightly longer than the fourth. Claws equal, strongly curved, short, about half the length of the fifth tarsal segment, each with a subapical tooth.

Empodium well developed, as long as the claws, hairy. *Abdomen* dark brown, well clothed with hairs. Spermatheca single, highly chitinated, with numerous minute clear areas basally, pyriform, about $140\ \mu$ by $95\ \mu$; the commencement of the duct, apart from the attenuated basal portion of the spermatheca, not at all chitinated.

NATAL: Ulundi, 5,000–6,500 ft., ix.1896, 2 ♀♀ (Dr. G. A. K. Marshall).

***Atrichopogon turneri*, sp. n.**

Length of body (one female), 1.3 mm.; length of wing, 1.1 mm.; greatest breadth of wing, 0.4 mm.

Head very dark brown, occiput sparsely clothed with dark hairs. Eyes sparsely hairy, the pubescence almost limited to the inner lateral margin adjoining the bases of the antennae; contiguous above, separated by a narrow line only. Clypeus paler brown. Proboscis dark brown, highly chitinated. Palpi dark brown, segments 2 to 5 measuring in the single female examined approximately 10, 12, 8, and 6 units respectively, the third segment somewhat inflated, furnished with a large sensory pit, the fifth small, tapering, almost conical. *Antennae* dark brown, hairs short. Segments 4 to 10 short and broad, all of about the same length but of gradually decreasing breadth, the fourth being about one and a half times as broad as long, the tenth subspherical. Segments 11 to 15 cylindrical, elongated, the length increasing from nearly three times to about five times the breadth, the last segment the longest and ending in a stylet about four units long. *Thorax* very dark brown, sparsely clothed with hairs. *Pleurae* dark brown. *Scutellum* dark brown, but not so dark as the mesonotum, bearing two lateral and two centro-marginal bristles but no small hairs. *Post-scutellum* very dark brown. *Wings* (fig. 10, a) clear, unadorned;

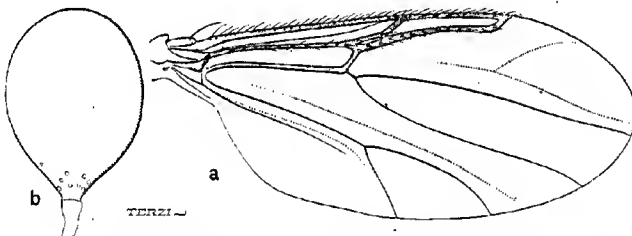


Fig. 10. *Atrichopogon turneri*, sp. n., ♀: a, wing (diagrammatic); b, spermatheca.

veins brownish. Wing surface densely clothed with rather large microtrichia, but without longer decumbent hairs. Venation as in *A. xanthoaspidium*. Halteres with whitish knobs. *Legs* brown, terminal tarsal segments somewhat infuscated, unarmed with spines, moderately hairy. First tarsal segment on the fore and middle legs more than, on the hind legs slightly less than, three times as long as the second; fifth segment rather longer than the fourth. Claws equal, strongly curved, small, about half the length of the fifth tarsal segment, each with a minute subapical tooth. Empodium well developed, as long as the claws, hairy. *Abdomen* dark brown but not so dark as the thorax, sparsely clothed with short hairs. Spermatheca (fig. 10, b) single, highly chitinated, bearing a few minute clear areas at its base, oval, about $58\ \mu$ by $47\ \mu$, and drawn out at the base towards the duct, which is chitinated for a short distance, about $7\ \mu$ at its commencement.

SOUTH AFRICA: Mossel Bay, Cape Province, ii.1922, 1 ♀ (R. E. Turner).

***Dasyhelea bolei*, sp. n.**

Length of body (one female), 2.1 mm.; length of wing, 1.4 mm.; greatest breadth of wing, 0.5 mm.

Head dark brown, the occiput dark brown in the middle, greyish at the periphery. Eyes densely hairy; broadly contiguous above, but the facets separated by a narrow line. Clypeus dark brown, hairy. Proboscis dark brown, very short. Palpi darkish brown; second segment very short, third the longest, about one and a half times the length of the fourth, without a sensory pit, but bearing on its inner aspect several (eight or nine) long sensory hairs, fifth rather longer than the fourth, hardly at all dilated at its end. *Antennae* dark brown, the torus darker than the flagellum, bearing short, dark brown hairs, and both long and short spines on all the flagellar segments. All the flagellar segments are also finely sculptured. Segments 4 to 14 short and broad, forming an almost continuous series, from subspherical to flask-shaped, their lengths ranging from one to one and a half times their greatest breadths; the fifteenth segment longer, ending in a large stylet about six units long. *Thorax* greyish pruinose with dark sepia-coloured markings and yellowish brown humeral patches. *Pleurae* dark brown. *Scutellum* yellowish brown, bearing a transverse row of ten marginal bristles and numerous (fifteen) small hairs, one of which is central, in the middle of the row of bristles. *Post-scutellum* very dark brown. *Wings* (fig. 11) almost unadorned, but slightly infuscated at the junction of the first and third veins with the costa; surface

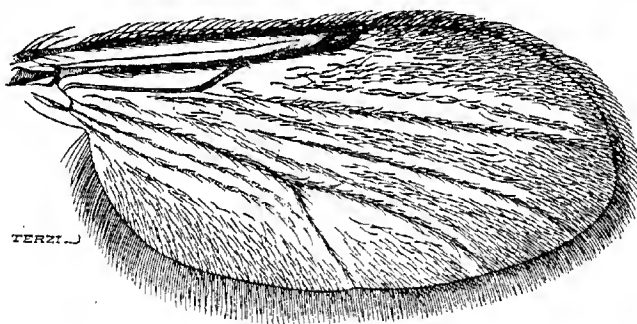


Fig. 11. *Dasyhelea bolei*, sp. n., wing of ♀.

densely clothed with long hairs which extend to the base. Third vein joining the costa slightly beyond the middle of the wing, and distal to the point of bifurcation of the fifth vein. First and third veins forming distally a small cell. Halteres brown, with brown knobs containing an almost white pigment. *Legs* brown, hairy, the knees darkened and the terminal tarsal segments somewhat infuscated, especially the fifth, which is entirely dark. Claws simple, equal, barely half the length of the fifth tarsal segment. *Abdomen* dark brown, hairy. *Spermatheca* single, highly chitinised, resembling that of *D. retorta*, but so far as could be made out in the specimen, which is somewhat collapsed, rather larger, about 57μ by 43μ , and the proximal portion slightly longer and more slender, about 33μ long and 9μ wide in the middle.

GOLD COAST (NORTHERN TERRITORIES): Bole, 3.ix.1911, 1 ♀ (*Dr. A. Ingram*).

This large species may be distinguished from *D. fusciformis*, C., I. & M., a smaller and paler brown species, by the characters of the palps, the number of small hairs on the scutellum, and the shape of the spermatheca. It resembles *D. retorta*, I. & M., in being a dark brown midge, with a yellowish scutellum and a retort-shaped spermatheca, but apart from its size, differs in the characters of the palps and in the numbers of bristles and hairs on the scutellum.

***Apelma bacoti*, sp. n.**

Length of body (one male), 1.5 mm.; length of wing, 1.3 mm.; greatest breadth of wing, 0.4 mm.

Head darkish brown, occiput rather densely clothed with hairs. Eyes bare, except on their inner margins, round the bases of the antennae, where they are hairy; contiguous above, separated only by a narrow line, and with a small conical projection in front of them in the middle line. Clypeus brown, sparsely clothed with hairs. Proboscis brown, short, rather poorly chitinated. Palpi pale brown, distal segments slightly infuscated, clothed with rather long hairs; first segment relatively large, second, fourth, and fifth about subequal, third about one-half longer, inflated, and with a well-developed sensory pit, fifth segment almost cylindrical. *Mouth-parts* poorly chitinated. *Antennae* dark brown with large dark brown plumes. *Torus* large. Segments 4 to 11 gradually decreasing in size and becoming more elongated anteriorly, the fourth subglobular, the eleventh about twice as long as broad and a little less than half the length of the twelfth segment. Segments 12 to 15 elongated, not binodose,

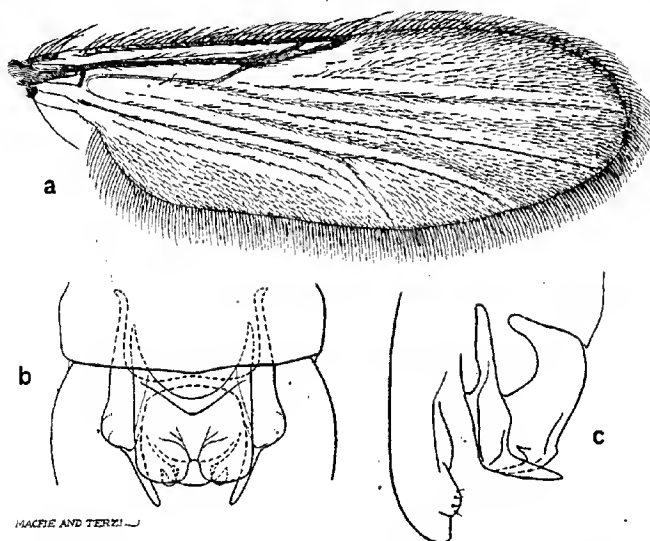


Fig. 12. *Apelma bacoti*, sp. n., ♂: a, wing; b, diagram of median structures of hypopygium, ventral view; c, outline of lateral view of hypopygium.

finely sculptured, subequal (in one instance 32, 34, 27, and 31 units respectively), about four times as long as broad, the last segment being the stoutest, tapering distally, and ending in a nipple-like process. *Thorax* brown, with pale brown humeral patches and a pale brown area just in front of the scutellum; well clothed with hairs. *Pleurae* pale brown. *Scutellum* pale brown, bearing a transverse row of seven or eight bristles and a few small hairs. *Post-scutellum* brown. *Wings* (fig. 12, a) narrow, densely clothed with decumbent hairs, which are most numerous on the distal half. *Fringe* long and fine. Third vein reaching only slightly beyond the middle of the wing, fused basally with the first vein, forming a single broad vein in place of the first cell, second cell small, elongated. Base of the lower ramus of the fourth vein obsolete, but bifurcation clearly proximal to the middle of the wing. Fork of the fifth vein on a level with the end of the third vein. *Halteres* pale brown with almost white knobs. *Legs* rather pale brown with the terminal tarsal segments infuscated; hairy. First tarsal segment three, or nearly three times as long as the second on all the

legs, the other tarsal segments cylindrical, successively a little shorter than the preceding ones. Claws equal, very slender, strongly curved, with bifid ends, and nearly as long as the fifth tarsal segments. Empodium absent or rudimentary. *Abdomen* darkish brown dorsally, paler brown ventrally; well clothed with longish brown hairs. *Hypopygium* (fig. 12, *b, c*): ninth segment with the tergite long and well developed, densely clothed with long hairs, posterior border rounded; sternite not excavated in the middle line posteriorly. Forceps large, hairy; the claspers of almost uniform thickness throughout, basal third densely clothed with minute hairs and bearing also a group of four larger hairs on the outer aspect. Harpes highly chitinised, fused so as to form an organ which in ventral view is somewhat H-shaped, the posterior limbs being, however, directed more or less ventrally and expanded and rather thinly chitinised basally. Aedoeagus highly chitinised, broad, shield-shaped, furnished at the posterior margin with two strong hooks or spines, which are directed dorsally.

SIERRA LEONE: Freetown, 1915, 3 ♂♂ (*A. Bacot*), reared from larvae found in the leaf axils of the "cocked-hat" tree (*Dracaena* sp.).

This species should be distinguished from *Apelma auronitens*, K., which also has the third vein reaching slightly beyond the middle of the wing and the bifurcation of the fifth vein on a level with the extremity of the third vein, and this may be done apparently by the general coloration, which is yellowish brown not brownish black, and by the terminal segments of the antennae of the male, the twelfth segment being subequal to the thirteenth and less than three times the length of the eleventh.

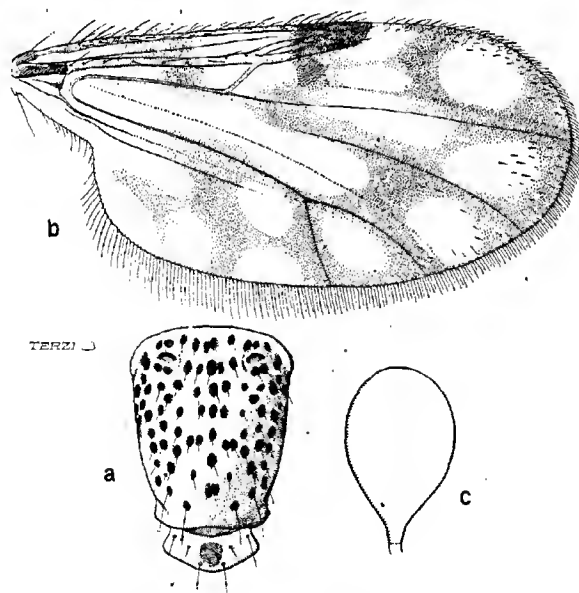


Fig. 13. *Culicoides adersi*, sp. n., ♀: a, thoracic adornment; b, wing; c, spermatheca.

***Culicoides adersi*, sp. n.**

Length of body (two females), 1.2 mm.; length of wing, 0.9 mm.; greatest breadth of wing, 0.4 mm..

Head dark brown. Eyes bare, except for a few point-like hairs at the inner lateral margin; narrowly separated above, by about 7 μ . Clypeus and proboscis darkish brown. Palpi darkish brown; the third segment strongly inflated, the

fourth and fifth small, subequal, nearly as broad as long. *Antennae* brown, the torus darker than the flagellum. Segments 4 to 10 subspherical to oval, subequal, the distal ones only slightly longer and narrower than the proximal ones. Segments 11 to 15 longer, the length from about one and a half to nearly three times the breadth; the last segment the longest, tapering distally, and bearing at its end a long hair. *Thorax* (fig. 13, *a*) grey-brown, with numerous small, rounded, dark brown spots which correspond with the points of insertion of hairs. Scutellum grey-brown laterally, darker brown in the middle; bearing two lateral and two centro-marginal bristles, and four small hairs. Post-scutellum dark brown, with a large greyish brown anterior patch. *Wings* (fig. 13, *b*) with extensive pale markings, as shown in the figure. Decumbent hairs very scanty, almost confined to the apical and posterior marginal areas, but most numerous in the distal anterior portion above the upper ramus of the fourth vein. Halteres with white or pale yellow knobs. *Legs* brown, with dark knees. Fourth tarsal segments short and broad. *Abdomen* darkish brown, the apices of the segments and the extremity of the body paler brown. *Spermathecae* (fig. 13, *c*) two, highly chitinated, pyriform, subequal, about 45μ by 30μ ; the bases of the spermathecae taper and pass insensibly into the duct.

KENYA: Lamu, 18.ii.1912, 5 ♀♀ (*Dr. S. A. Neave*). ZANZIBAR: Pigaduri, 18.ix.1917, 4 ♀♀, "biting natives" (*Dr. W. M. Aders*).

The wing markings of this insect resemble in a general way those of *Culicoides pallidipennis*, C., I. & M., but actually differ from them in many respects, for example, in the area covered by the dark spot near the middle of the anterior border. The thoracic adornment, and the colour of the halteres are also different. From *C. imicola*, Kieff., it may be distinguished apparently by the scantiness of decumbent hairs on the wings, and by the form of the basal flagellar segments of the antennae, which are shorter, subspherical.

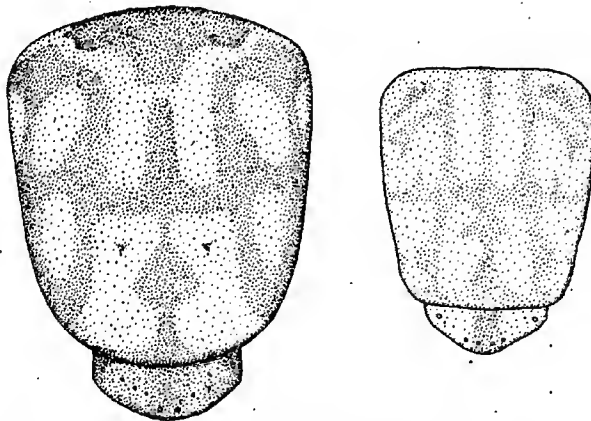


Fig. 14. Diagram of thoracic adornment of *Culicoides bedfordi*, sp. n. (left) and *Thysanognathus monostictus*, sp. n. (right).

***Culicoides bedfordi*, sp. n.**

Length of body (one male and one female), 1.3 mm.; length of wing, 1.2 mm.; greatest breadth of wing, ♂, 0.4 mm., ♀, 0.5 mm.

Head dark brown, occiput sparsely clothed with hairs. Eyes bare, narrowly separated above in both sexes. Clypeus dark brown. Proboscis brown, well chitinated. Palpi brown, second segment cylindrical, a little shorter than the third, third the longest, as long as the fourth and fifth together, inflated about the middle, furnished with a large sensory pit, fourth and fifth subequal, short, about half the length of

the third, the fifth hardly dilated at its ends. *Mouth-parts* well chitinated; mandibles of the female bearing about nine minute teeth on the inner distal border. *Antennae* almost uniformly brown, but the torus darker than the flagellum segments. In the female, third segment rather large; segments 4 to 10 subspherical to oval, length from about one to one and a third times the breadth; segments 11 to 14 elongated, cylindrical, subequal, about three times as long as broad; the fifteenth similar, slightly longer, ending bluntly. In the male, plume well developed, darkish brown; the last three segments elongated, the thirteenth longer than the fifteenth. *Thorax* (fig. 14, left) dark brown with paler brown markings, as shown in the diagram. *Pleurae* darkish brown. *Scutellum* darkish brown, bearing two lateral and two centro-marginal bristles and a few (about six) small hairs. *Post-scutellum* dark brown,

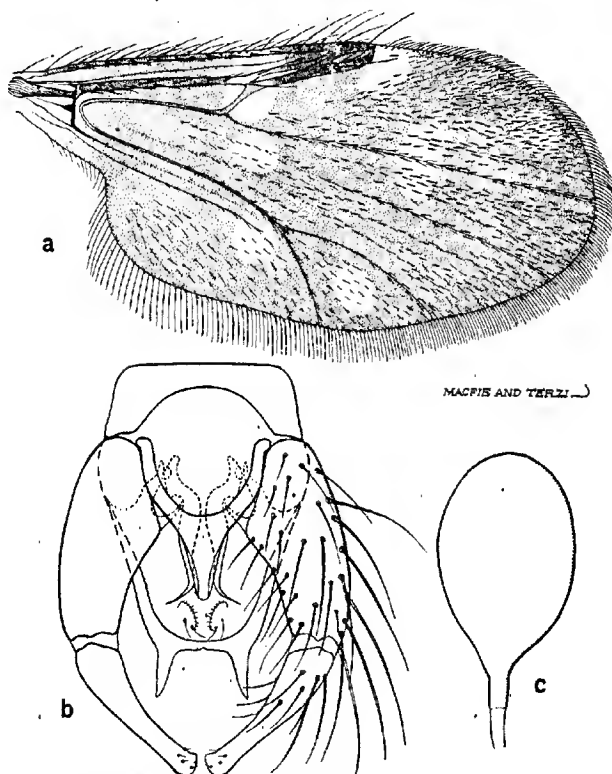


Fig. 15. *Culicoides bedfordi*, sp. n.: a, wing of ♀; b, diagram of hypopygium of ♂, ventral view; c, spermatheca.

with a paler brown patch anteriorly. *Wings* (fig. 15, a) pale grey with pale-coloured spots, as shown in the figure; somewhat resembling *C. fulvithorax*, Aust., but more hairy. First pale spot near the middle of the anterior border of the wing enveloping the cross-vein and the proximal portion of the first interspace, and reaching to the costa. Pale spot at the end of the costa covering at most the extreme tip of the costa and third vein. Very faint indications of peripheral pale spots are visible in the usual situations. In the male the wings are paler than in the female and the pale spots are less distinct. The wings in both sexes are relatively densely clothed with

decumbent hairs, which extend between the fourth and fifth veins beyond the middle of the wings but not to the base. Halteres with white knobs. Legs brown, femora and tibiae somewhat infuscated, with darker knee spots, the tibiae with pale sub-basal bands, and the fore and middle femora with similar but less distinct pale bands subapically. Abdomen darkish brown, sparsely clothed with brown hairs. Spermathecae (fig. 15, c) two, well chitinised, oval or pyriform, subequal, about 47μ by 36μ ; the commencement of the duct chitinised for a short distance, about 10μ . Hypopygium (fig. 15, b): ninth segment with the tergite slightly notched in the middle line posteriorly, and bearing well-developed lateral finger-like processes, which are about three or four times as long as their width in the middle; sternite with a wide, rather shallow, notch posteriorly. Forceps of the usual form; claspers not very highly chitinised, ending bluntly. Harpes in the form of two long, narrow, unbranched chitinous processes, somewhat similar to those of *C. clarkei*. Aedoeagus Y-shaped; stem large and broad, rather thinly chitinised posteriorly; limbs highly chitinised, stout, in ventral view slightly everted at their bases, forming a semicircular arch. Ventral wall not chitinised, not differentiated from the membrane joining it to the ninth sternite, which is not studded with spicules.

TRANSVAAL: Onderstepoort, 22.ix.1914, 1 ♀ and 2 ♂♂, one labelled as taken in a bedroom at 6 a.m. (*G. Bedford*).

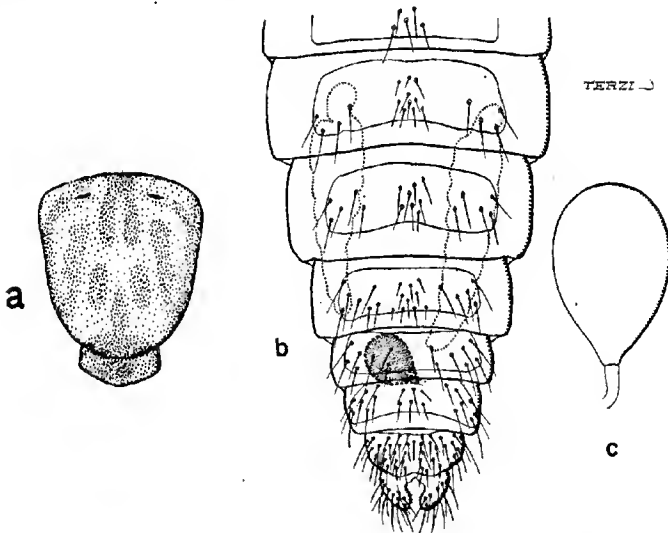


Fig. 16. *Culicoides praetermissus*, C., I. & M., ♀: a, thoracic adornment (diagrammatic); b, posterior extremity of abdomen, dorsal view; c, spermatheca.

***Culicoides praetermissus*, C., I. & M.**

Length of body (one female), 1.7 mm.; length of wing, 1.5 mm.; greatest breadth of wing, 0.7 mm.

Head dark brown. Eyes separated above by about 18μ . Clypeus and proboscis dark brown. Palpi dark brown, third segment slightly longer than the second, strongly inflated, furnished with a large sensory pit, fourth and fifth segments subequal, less than half the length of the third, the fifth not dilated at its end. Antennae dark brown, but the basal segments of the flagellum somewhat paler than the rest. Segments 4 to 10 subspherical to oval, the length ranging from a little over one to

nearly one and a half times the breadth. Segments 11 to 14 elongated, from about two and a half to three times as long as broad, the fifteenth somewhat larger and longer, ending in a conical tip. *Thorax* (fig. 16, *a*) dark brown, with paler brown markings, as shown in the diagram. *Pleurae* dark brown. *Scutellum* dark brown, paler brown at the sides, bearing four lateral and three central bristles and several (about eight) small hairs. *Wings* with markings as in the male. *Halteres* with whitish knobs, which are infuscated at their bases. *Legs* brown; femora and tibiae infuscated, with darker knee spots, and narrow pale bands on both sides of them on the fore legs, and on the tibial side on the middle and hind legs. *Abdomen* (fig. 16, *b*) dark brown. *Spermatheca* (fig. 16, *c*) single, highly chitinated, pyriform, about 90 μ by 60 μ ; the commencement of the duct chitinated for a short distance only, about 4 μ .

TRANSVAAL: Onderstepoort, 25.xi.1913, 1 ♂, "caught in laboratory"; 26-27.i.1914, 2 ♂♂, "caught in laboratory 9 a.m. and 10 a.m.," and 1 ♀, "in laboratory 8.30 p.m."; 22-23.iv.1914, 3 ♀♀ "caught in laboratory"; 22.ix.1914, 1 ♀, "in bedroom 6 p.m." (*G. Bedford*).

The male of this species has previously been described (1920). Edwards (1922) has drawn attention to the resemblance of this insect to *C. guttifer*, de Meij.; and has suggested that it is highly questionable if the differences between the two species "indicate more than a varietal rank for *C. praetermissus*." We are inclined, however, to attach more importance than he does to the presence of a small pale spot immediately below and distal to the second large costal spot, and in our opinion the wing of *C. guttifer* shown in his figure more closely resembles that of *C. distinctipennis*, Aust., than that of *C. praetermissus*. Edwards also remarks: "So far as I can see, from an examination of the type, Kieffer's *C. leucostictus*, described from females only from the Seychelles Islands, is identical with *C. guttifer*." The wing of *C. leucostictus* appears to us to resemble closely that of *C. praetermissus*, but in Kieffer's figure, the accuracy of which we have no reason to doubt, there are several well-marked differences, for example, the dark spot near the middle of the anterior margin of the wing covers the whole of both radial cells, the first pale costal spot lies proximal to the cross-vein, and the second pale costal spot does not reach to the anterior margin of the wing.

***Culicoides neavei*, Aust.**

TRANSVAAL: Onderstepoort, 27.i.1914, 1 ♀, "in laboratory, 11 a.m." (*G. Bedford*).

***Culicoides nigeriae*, I. & M.**

SIERRA LEONE: Kaballa, 14.xi.1913, 2 ♀♀, (*Dr. J. Y. Wood*); v.1914, 7 ♀♀ (*Dr. J. S. Pearson*). NIGERIA (NORTHERN PROVINCES): Baro, x.1910, 5 ♀♀ (*Dr. A. Ingram*); Ibi, 1-4.x.1911, 2 ♀♀ (*Dr. J. McF. Pollard*). NIGERIA (SOUTHERN PROVINCES): Mokwa, 27.x.1909, 2 ♀♀, "bites 9 a.m. to 3 p.m." (*Dr. T. F. G. Mayer*).

***Culicoides pallidipennis*, C., I. & M.**

TRANSVAAL: Onderstepoort, 1913 and 1914, several specimens of both sexes, some labelled as caught in a laboratory (*G. Bedford*).

***Culicoides schultzei*, End.**

TRANSVAAL: Onderstepoort, 27.i.1914, 1 ♀, "in laboratory, 10 a.m." (*G. Bedford*).

***Culicoides similis*, C., I. & M.**

TRANSVAAL: Onderstepoort, 25.xi.1913, 1 ♂, "caught in laboratory," and 22-23.iv.1914, 2 ♀♀, "on window" (*G. Bedford*).

***Thysanognathus monostictus*, sp. n.**

Length of body (two females), 1.3 mm.; length of wing, 1.0 mm.; greatest breadth of wing, 0.4 mm.

Head brown, occiput dark brown in the middle, pale brown at the periphery; sparsely clothed with brown hairs. Eyes densely hairy; contiguous above, the

facets separated only by a narrow line. Clypeus and proboscis brown. Palpi pale brown, slightly darker at the end; second, fourth, and fifth segments subequal, third nearly twice as long as the fourth, without a sensory pit but bearing sensory hairs on its inner aspect, fourth a little shorter than the fifth, fifth slightly dilated at its end. *Mouth-parts* as in *T. marmoratus*. *Antennae* darkish brown, the first segment and torus darker than the other segments, short, the terminal segments sculptured and all the flagellar segments bearing both long and short spines. Segments 4 to 14 subspherical to oval, forming an almost continuous series, the length ranging from just over one to nearly one and a third times the greatest breadth; the last segment longer, about twice as long as broad, ending bluntly. *Thorax* (fig. 14, right) brown, with paler markings as shown in the diagram; sparsely clothed with brown hairs. *Pleurae* brown, with paler brown markings. *Scutellum* pale brown laterally, darker brown in the middle; bearing two lateral and three or four

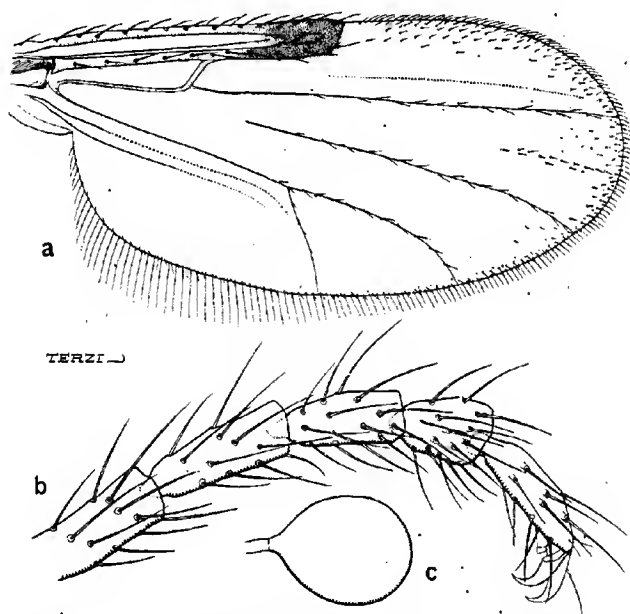


Fig. 17. *Thysanognathus monostictus*, sp. n., ♀: a, wing; b, termination of hind leg; c, spermatheca.

centro-marginal bristles. Post-scutellum darkish brown. *Wings* (fig. 17, a) hyaline, with a single dark brown spot covering the extremities of the costa and first and third veins. Venation as shown in the figure; petiole of the fourth vein short; bifurcation of the fifth vein about the level of the base of the single radial cell. Wing surface devoid of microtrichia. Decumbent hairs scanty, most numerous along the anterior margin near the tip of the wing, and a few present between the rami of the fourth vein; between the lower ramus of the fourth vein and the upper ramus of the fifth, and along the veins. Halteres with white knobs. *Legs* almost colourless, with dark brown knees and tibio-tarsal joints, slight infuscation at the apices of the first four and over the whole of the fifth tarsal segments, and dark bands (most pronounced on the fore legs) about the middles of the femora and tibiae. Fourth tarsal segments nearly bell-shaped. *Claws* (fig. 17, b) equal, small, about half the

length of the fifth tarsal segment. Empodium minute. *Abdomen* when unexpanded appears dark brown, darker than the thorax, with pale-coloured apical bands on the segments and a pale extremity, when fully expanded, however, it is seen that the tergites have both basal and apical pale bands, and that the eighth segment is entirely dark brown. Spermatheca (fig. 17, c) single, very highly chitinated, oval, about $32\ \mu$ by $25\ \mu$; the commencement of the duct chitinated for only a short distance, about $4\ \mu$.

ZANZIBAR: Prison, 1.xii.1918, 4 ♀♀ (Dr. W. M. Aders).

This insect differs in two important respects from the other species which we have referred to the genus *Thysanognathus*, namely, in possessing hairy eyes and small claws. It may be noted with regard to the eyes that in some of the other species they are not entirely bare, so that apparently in this genus, as in *Atrichopogon*, the character is of specific rather than generic value.

***Stilobezzia ugandae*, sp. n.**

Length of body (one female), 1.2 mm.; length of wing, 1.1 mm.; greatest breadth of wing, 0.45 mm.

Head dark brown, occiput sparsely clothed with dark brown hairs. Eyes bare, except on the borders adjoining the bases of the antennae where they bear minute hairs, separated above by a wedge-shaped area. Clypeus dark brown, sparsely clothed with hairs. Proboscis dark brown, short, well chitinated. Palpi darkish brown, short and stumpy, the first segment very small, the four following segments

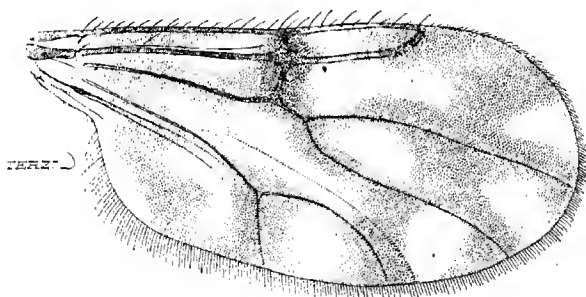


Fig. 18. *Stilobezzia ugandae*, sp. n., wing of ♀.

measuring in the single specimen examined about 5, 6, 4, and 7 units respectively; the third segment inflated, and furnished with a well-developed sensory pit, the fifth slightly dilated at its end. *Mouth-parts* well but not very strongly chitinated; mandibles armed with about six small teeth. *Antennae* brown, proximal segments of the flagellum paler brown at their bases, hairs rather short and scanty. Torus darker brown, subspherical, bearing a few small hairs. Third segment slightly larger than the fourth. Segments 4 to 10 subcylindrical, length gradually increasing from about two and a half to three and a half times the breadth. Segments 11 to 14 longer, subequal, about four or five times as long as broad; the fifteenth segment slightly longer, about six times as long as broad, and ending in a bluntly-pointed process. *Thorax* dark brown, sparsely clad with moderately large hairs. No adornment distinguishable in the specimen examined, which, however, was old and partly disfigured with mounting fluid. Pleurae dark brown. Scutellum dark brown, bearing two centro-marginal and two lateral bristles, but no small hairs. Post-scutellum dark brown. *Wings* (fig. 18) infuscated, with darker patches over the region of the cross-vein and the end of the costa, and pale areas at the periphery between the veins and in the middle portion of the wing, as shown in the figure.

First cell very small, lozenge-shaped, second large. First vein very short, third joining the costa at about three-quarters of the length of the wing from the base, fourth with a long petiole, fifth forking at about the level of the cross-vein. Halteres with darkish brown knobs. Legs brown, with pale bands just above and just below the knees. Femora unarmed, not swollen. First tarsal segment much longer than the second on the fore and middle legs, second as long as the third and fourth together, third short and broad or bell-shaped, fourth cordiform, and fifth slightly swollen distally and a little shorter than the second. Claws fused, unequal, the one very small, the other about three-quarters the length of the fifth tarsal segment, or they might be described as single with a basal barb. The terminal segments of the hind tarsi unfortunately missing from our specimen. Empodium very small, hair-like. Abdomen dark brown, very sparsely clothed with hairs. No spermatheca could be distinguished even after treatment with caustic potash.

UGANDA: 1910, 1 ♀ (Capt. A. D. Fraser).

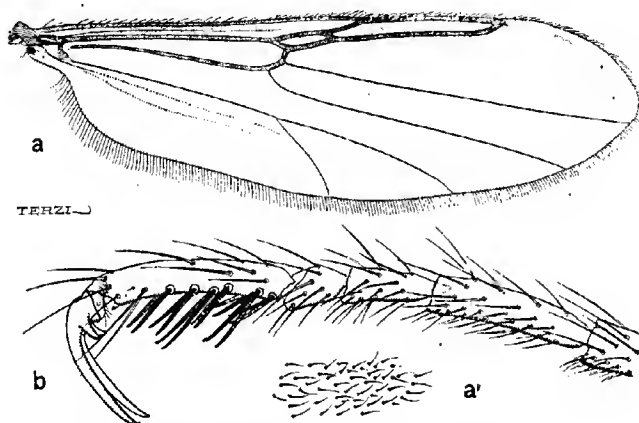


Fig. 19. *Sphaeromias turneri*, sp. n., ♀: a, wing; a', microtrichia of wing highly magnified; b, termination of hind leg.

***Sphaeromias turneri*, sp. n.**

Length of body (one female), 4.2 mm.; length of wing, 3.3 mm.; greatest breadth of wing, 0.9 mm.

Head very dark brown, occiput clothed with dark hairs. Eyes bare, separated above by a wedge-shaped area. Clypeus dark brown, hairy. Proboscis dark brown, well chitinated. Palpi dark brown, long and slender, the four terminal segments measuring in the single female examined 18, 26, 22, and 27 units respectively; the third segment nearly four times as long as broad, not inflated, without a sensory pit but bearing sensory hairs on its basal half, the fifth broadest and rounded at its end. Mouth-parts highly chitinated, the mandibles armed distally with about ten strong teeth. Antennae uniformly dark brown, the torus, however, rather paler than the flagellum segments, very sparsely clothed with hairs. Third segment twice as long as the fourth. Segments 4 to 10 subequal, subcylindrical, two and a half times as long as broad. Segments 11 to 15 more elongated, subequal, about five times as long as broad, the last being slightly longer and ending in a conical tip. Thorax uniformly very dark brown, almost black, well clothed with short, black hairs, without a median spine on its anterior border. Pleurae very dark brown. Scutellum uniformly very dark brown, bearing a transverse row of about seven bristles and numerous small hairs. Post-scutellum very dark brown. Wings (fig. 19, a) slightly infuscated, especially along the anterior margin, and the anterior veins darkish

brown. Third vein joining the costa at about three-quarters of the length of the wing from its base. Second cell about three times as long as the first. Bifurcation of the fifth vein at about the same level as the cross-vein, that of the fourth vein slightly proximal to it. Wing surface densely clothed with large microtrichia (fig. 19 *a*) but without macrotrichia. Halteres with dark brown knobs, densely clothed with microtrichia and bearing also a few small hairs. Legs brown, moderately hairy, with the knees, the apices of the tibiae and the first two tarsal segments, and the whole of the last three tarsal segments dark brown. On the hind legs the infuscation on the knees extends over the basal third of the tibiae. Femora not swollen, unarmed. First tarsal segment about twice as long as the second on all the legs, second longer than the third and fourth together, third cylindrical but slightly broadened at the apex, fourth bell-shaped or almost cordiform, fifth longer than the third and fourth together, armed with several (a dozen or more) black spines or batonnets. Claws (fig. 19, *b*) on all the legs equal, about three-quarters the length of the fifth tarsal segment, each bearing a well-developed basal barb. Empodium absent. *Abdomen* dark brown, clothed with short hairs. On the ventral aspect of the eighth segment are submedian tufts of long bristles. *Spermæthecae* two, highly chitinated, subequal, subspherical, diameter about 90μ ; the commencement of the duct is chitinated for only a short distance, about 8μ .

SOUTH AFRICA: Ceres, Cape Province, iii.1921, 1 ♀ (*R. E. Turner*).

***Palpomyia ashantii*, sp. n.**

Length of body (one female), 3.8 mm.; length of wing, 3.1 mm.; greatest breadth of wing, 0.8 mm.

Head very dark brown; occiput sparsely clothed with dark brown hairs. Eyes bare, widely separated above by a wedge-shaped area. Clypeus dark brown, sparsely clothed with hairs. Proboscis dark brown, well chitinated. Palpi dark brown; first segment small, second and fourth subequal, third and fifth rather larger, subequal, the former not inflated and without a sensory pit but bearing sensory hairs on its distal half, the latter slightly expanded at its distal end. *Mouth-parts* well chitinated; mandibles armed distally with about nine strong teeth. *Antennae*: torus dark brown, flagellum lighter brown, the basal segments infuscated apically and the last five over almost their entire lengths; hairs scanty, the basal segments bearing also long, slender spines. First segment small. Torus bearing a few hairs. Third segment less than twice the length of the fourth, cylindrical, tapering basally. Segments 4 to 10 from almost cylindrical to elongated flask-shaped, subequal, about five times as long as broad. Segments 11 to 15 elongated, nine or ten times as long as broad, the last slightly the longest and ending in a blunt point. *Thorax* uniformly very dark brown, almost black, sparsely clothed with hairs, bearing a minute spine at the middle of its anterior margin. Pleurae dark brown. Scutellum very dark brown, bearing a transverse row of five bristles and a few small hairs. Post-scutellum almost black. *Wings* (fig. 20, *a*) slightly infuscated, especially along the anterior margin. Surface densely clothed with minute microtrichia, but without macrotrichia. Third vein joining the costa at about five-sixths of the length of the wing from the base; second cell rather more than twice as long as the first. Bifurcation of the fourth vein a little proximal to the cross-vein, that of the fifth vein nearly at the same level as the cross-vein. Halteres with almost black knobs. *Legs*, with femora and tibiae, very dark brown, and tarsi paler brown, but with the terminal segments more or less infuscated. Fore legs: femora armed on the distal third with four or five black spines; tibiae with a pale brown apical spine; first tarsal segment more than twice as long as the second, third cylindrical, fourth cordiform, fifth about as long as the third, unarmed. Middle legs: femora armed on the distal third with a single black spine; tibiae bearing a dark apical spine; first three tarsal segments bearing a pair of apical spines, first segment nearly four times as long as the second, third cylindrical, fourth cordiform, fifth about as long as the third, unarmed. Hind legs: femora armed near the apex with two black spines; first tarsal segment nearly

three times as long as the second, third cylindrical, fourth cordiform, fifth about as long as the third, unarmed. Claws on all the legs equal, rather more than half the length of the fifth tarsal segment, each bearing a very small basal barb. Abdomen very dark brown, sparsely clothed with short, dark brown hairs. Spermathecae (fig. 20, b) two, highly chitinated, small, subspherical to oval, subequal, diameter about $50\ \mu$; commencement of the duct chitinated for a short distance only (about $7\ \mu$).

GOLD COAST (ASHANTI): Obuasi, 27.vi.1907, 1 ♀ (Dr. W. M. Graham), "caught in bush."

This species does not fall into any of the subgenera suggested by Kieffer (1917) for the non-European species of *Sphaeromyia* and *Palpomyia*, since the claws on all the legs are large, equal, but not simple, the fourth tarsal segments cordiform, and the fifth not armed with batonnets.

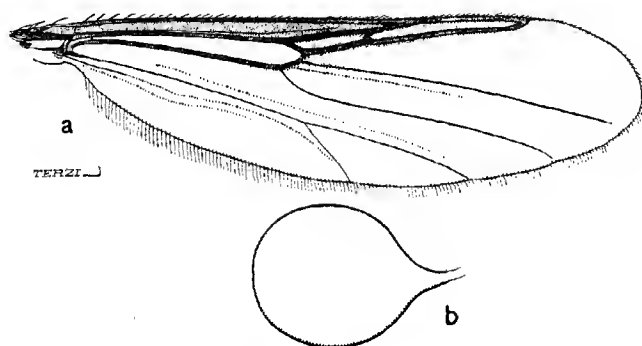


Fig. 20. *Palpomyia ashanii*, sp. n. ♀: a, wing; b, spermatheca.

***Palpomyia (Dicrohelea) grahami*, sp. n.**

Length of body (one female), 4.0 mm.; length of wing, 3.3 mm.; greatest breadth of wing, 0.9 mm.

Head dark brown, occiput rather densely clothed with hairs. Eyes bare, narrowly separated above. Clypeus dark brown, hairy. Proboscis dark brown, well chitinated. Palpi darkish brown: first segment small, remaining segments measuring respectively about 24, 35, 16, and 20 units, the third decidedly the longest, not inflated, without a sensory pit but bearing sensory hairs on its distal third, the fifth slightly dilated at its end. *Mouth-parts* strongly chitinated; mandibles armed on the distal part with eight well-developed teeth. *Antennae* brown, hairs short and sparse. First segment dark brown, small, bearing one or two small hairs. Torus dark brown, bearing a few short hairs. Third segment lighter brown, infuscated apically, slightly larger and longer than the fourth. Segments 4 to 10 light brown with infuscated apices, cylindrical, subequal, about four times as long as broad. Segments 11 to 15 darker brown, elongated, subequal, about twelve to fourteen times as long as broad, the eleventh and fifteenth slightly longer than the others, the latter terminating bluntly. *Thorax* very dark brown, rather densely clothed with short hairs and bearing at the middle of its anterior border a very small erect tubercle or spine. *Pleurae* very dark brown. *Scutellum* very dark brown, densely clothed with small hairs similar to those on the mesonotum, and bearing a transverse row of six bristles. *Post-scutellum* very dark brown. *Wings* (fig. 21, a) clear, very slightly infuscated at the anterior margin, tip somewhat pointed. Surface densely covered with minute microtrichia, but without macrotrichia. Third vein joining the costa at about five-sixths of the length of the wing from its base; second cell over four

times as long as the first. Bifurcation of the fourth vein slightly proximal to the cross-vein, that of the fifth vein at about the same level or slightly more proximal. Halteres with very dark brown knobs. Legs brown, with dark knees and infuscation at the apices of the first four tarsal segments and over the whole of the fifth. Femora armed on their distal halves with short black spines, variable in number, in one female, six or seven on the fore legs, two or three on the middle legs, and six on the hind legs. First tarsal segment on all the legs more than twice the length of the second, third cylindrical, fourth short, bell-shaped or almost cordiform on the fore and middle legs, but longer and cylindrical on the hind legs, fifth segment elongated on all the legs and armed with six pairs of rather long black spines or batonnets. Claws on the fore legs equal, rather long, about three-quarters the length of the fifth tarsal segment, each with a basal barb about one-third its length; on the middle and hind legs unequal, the one large and with a small barb as on the fore legs, the other quite small but also bearing a barb, which is relatively large. Abdomen slender, very dark brown, sparsely clothed with short hairs, and with traces of white markings dorsally at the posterior extremity, which, however, owing to the age of the specimen and its shrunken condition could not be clearly distinguished. Cerci pale brown. Spermathecae two, highly chitinated, subspherical, subequal, diameter, so far as could be judged from the specimen, in which they were partially collapsed, about $140\ \mu$; the commencement of the duct apparently not at all chitinated. Hypopygium (fig. 21, b, c): attached to the female was the hypopygium of a male, which, as it

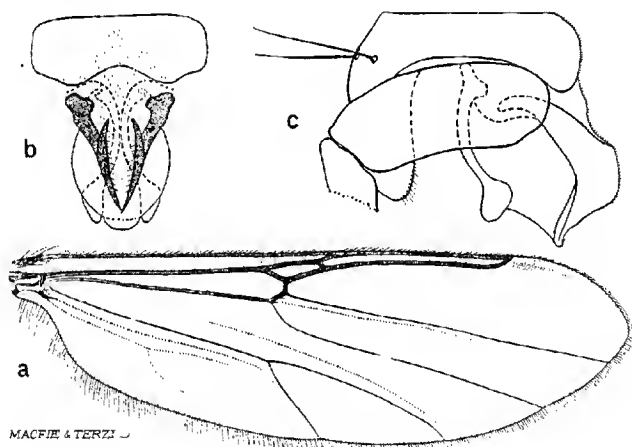


Fig. 21. *Palpomyia grahami*, sp. n.: a, wing of ♀; b, diagram of median structures of hypopygium of ♂, ventral view; c, outline of hypopygium of ♂, lateral view.

belonged presumably to the male of this species, is here briefly described. In most respects it resembled that of *Palpomyia pistiae*, I. & M., which we have described elsewhere (1922). Ninth segment very short; tergite short, bearing a few bristles; sternite very short, slightly excavated in the middle line posteriorly, without bristles. Forceps much as in *P. pistiae*. Harpes similar to those of *P. pistiae*, with the distal portion club-like with an expanded end. Aedoeagus large, much as in *P. pistiae*, but highly chitinated portion more pointed posteriorly. Ventral surface of the aedoeagus and the membrane joining it to the ninth sternite covered with minute hairs.

NIGERIA (SOUTHERN PROVINCES): Yaba, near Lagos, 11.viii.1909, 1 ♀ (*Dr. W. M. Graham*) "in bush, 10 a.m.," and 12.ix.1909, 1 ♀ (*Dr. W. M. Graham*) "in bush." To the latter specimen were attached the hypopygium and terminal abdominal segments of a male.

This species should apparently be assigned to the subgenus *Dicrohlelea*, erected by Kieffer (1917) for the reception of five Oriental species, the chief characteristics of which are: claws equal on the fore legs, unequal on the other legs, all with barbs; fourth tarsal segments cylindrical, not cordiform; fifth tarsal segments armed with dark batonnets; venation of the wing as in *Palpomyia*.

***Palpomyia nigeriae*, sp. n.**

Length of body (one female), 2.8 mm.; length of wing, 2.4 mm.; greatest breadth of wing, 0.7 mm.

Head very dark brown, almost black; occiput sparsely clothed with very dark brown hairs. Eyes bare, widely separated above by a wedge-shaped area. Clypeus dark brown, hairy. Proboscis dark brown, well chitinated. Palpi (fig. 22, *a*) dark brown, bearing only a few large hairs, tapering both apically and basally; first segment small, second and fourth subequal, the latter being slightly the smaller,

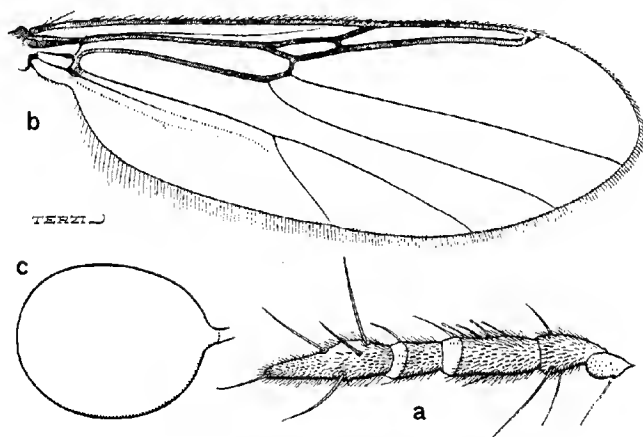


Fig. 22. *Palpomyia nigeriae*, sp. n., ♀: *a*, palp; *b*, wing; *c*, spermatheca.

third and fifth subequal, the former not inflated, without a sensory pit, the distal half of the fifth segment somewhat attenuated. *Mouth-parts* highly chitinated; mandibles strongly developed, with seven large teeth at the distal end. *Antennae* almost uniformly darkish brown, rather sparsely clothed with shortish brown hairs, and bearing long, slender, spines on the basal segments. First segment small. Torus bearing a few short hairs. Third segment about twice as long as the fourth, basal portion pale brown, tapering. Segments 4 to 10 oval, subequal, only slightly longer than broad, the distal segments a little longer and more slender than the proximal ones. Segments 11 to 15 elongated, subequal, four or five times as long as broad, the last being the longest and terminating in a blunt point. *Thorax* uniformly very dark brown, almost black, clothed with very dark hairs. Anterior thoracic spine rudimentary. *Pleurae* very dark brown. *Scutellum* very dark brown, almost black, bearing a transverse row of about a dozen alternating bristles and small hairs. *Post-scutellum* very dark brown, almost black. *Wings* (fig. 22, *b*) clear, unadorned.

Surface densely clothed with minute microtrichia, but without macrotrichia. Third vein joins the costa at about four-fifths of the length of the wing from its base; second cell more than three times as long as the first. Bifurcation of the fourth vein slightly proximal to the cross-vein, that of the fifth vein at about the same level. Halteres with almost black knobs. *Legs*: femora and tibiae very dark brown, tarsal segments paler but the terminal ones somewhat infuscated. Fore legs: femora armed with about six short, dark, spines which are distributed along the whole length of the lower surface; first tarsal segment a little more than twice the length of the second, third short and broad, fourth cordiform, fifth elongated, as long as the third and fourth together, armed ventrally with four or five pairs of dark spines; claws equal, about half the length of the fifth tarsal segment or a little longer, each with a small, stout, basal barb. Middle legs: femora armed near the apex with one or two short dark spines; terminal tarsal segments missing from the single specimen examined. Hind legs: femora armed on the apical third with three or four short dark spines; tibiae bearing several spine-like hairs; first tarsal segment more than twice (nearly three times) as long as the second, third short, cylindrical, fourth cordiform, fifth elongated, armed with four or five pairs of dark spines. Claws unequal, the one rather more than half the length of the fifth tarsal segment, the other quite small, each bearing a small basal barb. *Abdomen* very dark brown, sparsely clothed with short dark hairs. Spermathecae (fig. 22, c) two, highly chitinated, oval, subequal, about $105\ \mu$ by $65\ \mu$; the commencement of the duct chitinated for a short distance only (about $10\ \mu$).

NIGERIA (NORTHERN PROVINCES): Zungeru, 15.xi.1910, 1 ♀ (Dr. J. W. S. Macfie).

This species, in which the claws are equal and barbed on the fore legs and unequal and barbed on the hind legs, the fourth tarsal segments cordiform, and the fifth tarsal segments armed with batonnets, does not fall into any of the subgenera proposed by Kieffer (1917) for the non-European species of this group.

***Palpomyia pistiae*, I. & M.**

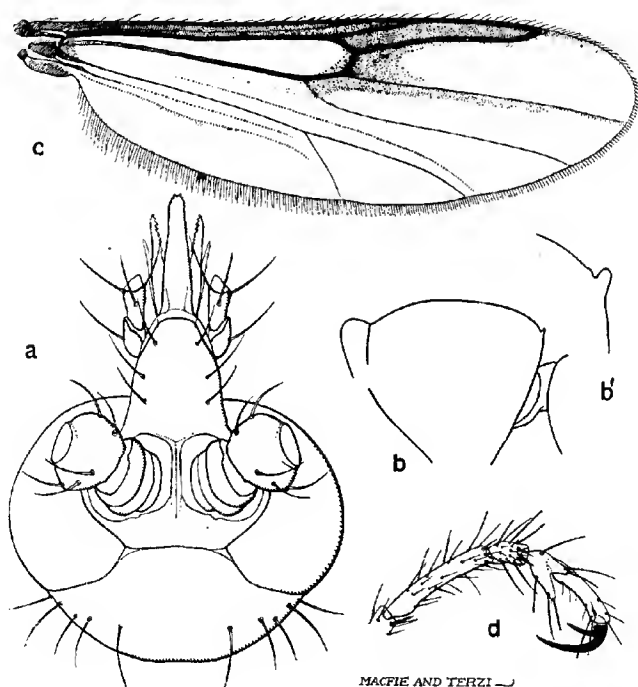
NIGERIA (SOUTHERN PROVINCES): Yaba, 11.ix.1909, 1 ♀, "hovering"; 30.viii.1909, 1 ♀, "in bush" (Dr. W. M. Graham).

***Ceratobezzia nigeriae*, sp. n.**

Length of body (one female), 3.4 mm.; length of wing, 2.2 mm.; greatest breadth of wing, 0.6 mm.

Head (fig. 23, a) very dark brown, almost black; very sparsely clothed with almost black hairs. Eyes bare, separated very widely above, by about 0.2 mm. Clypeus very dark brown, sparsely clothed with dark brown hairs. Proboscis dark brown, short, strongly chitinated. Palpi missing excepting the first two segments on one side, which are dark brown. *Mouth-parts* highly chitinated. Mandibles highly chitinated, strongly toothed, resembling those of *Thysanognathus marmoratus*, C., I. & M. *Antennae*: first segment almost black, small, apparently hairless. Torus dark brown, bearing only a few small hairs. Flagella missing. *Thorax* (fig. 23, b, b¹) uniformly very dark brown, almost black, very sparsely clothed with black hairs, and armed at the middle of its anterior margin with a very small erect spine or horn. Pleurae very dark brown. Scutellum uniformly very dark brown, bearing three centro-marginal bristles, and on each side two lateral bristles. Post-scutellum very dark brown, almost black. *Wings* (fig. 23, c) brownish, especially near the anterior border, round the anterior cross-vein, and along the upper ramus of the fourth vein. Veins, especially the anterior ones, dark brown. First vein short, less than half the length of the third. Third vein joins the costa about five-sixths of the length of the wing from the base. Bifurcation of the fourth and fifth veins at about the same level and some distance proximal to the anterior cross-vein. Fringe short. Surface of the wing densely clothed with minute microtrichia, but

without macrotrichia. Halteres with brown stems and white knobs. *Legs* (fig. 23, *d*) very dark brown, almost black, except the first two segments of the tarsi, which are pale brown with infuscated apices. Femora not swollen, unarmed. On the middle and hind legs the third tarsal segments short, but longer than broad; fourth bilobed, each lobe produced ventrally into a process armed at its end with two stout, black, spines or bristles; fifth rather long, unarmed, not swollen. Tarsi of fore legs missing. Claws on the middle and hind legs fused basally, unequal, the one as long as the fifth tarsal segment, the other about a third shorter. Empodium minute, hair-like. *Abdomen* very dark brown, almost black, excepting the posterior extremity and cerci, which are white. Ventral surface rather paler than the dorsal, segments 2 to 6 each with a darker heart-shaped mark in the middle line posteriorly. Abdomen long and slender, more than twice the length of the thorax, not petiolate; very sparsely clothed with short, dark, hairs. Spermatheca single, highly chitinated, subspherical, diameter about $70\ \mu$; commencement of the duct narrow, arising obliquely, and chitinated for only a short distance (about $10\ \mu$).



MACFIE AND TERZI

Fig. 23. *Ceratobezzia nigeriae*, sp. n., ♀: *a*, head, dorsal view; *b*, outline of thorax, lateral view; *b*¹, median spine on anterior border of thorax more highly magnified; *c*, wing; *d*, termination of middle leg.

NIGERIA (SOUTHERN PROVINCES): "The Lake of Life," near Ikotobo, Eket district, 28.xii.1913, 1 ♀ (*Dr. J. W. S. Macfie*).

The specimen, unfortunately, was damaged, the greater part of the palp, the flagellar segments of the antennae, and the tarsi of the fore legs being missing. We have tentatively referred it to the genus *Ceratobezzia*, however, because it appears

to resemble the type species of that genus, *C. fallax*, K., although it may be distinguished from it by a number of characters, such as the colour of the halteres, the ratio of the lengths of the first and third veins of the wings, and the form of the third tarsal segments of the middle legs.

***Tetrabezia argentea*, sp. n.**

Length of body (one female), 6.6 mm.; length of wing, 4.7 mm.; greatest breadth of wing, 1.1 mm.

Head rather dark brown, of the usual shape, not semispherical; occiput clothed with rather short hairs. Eyes bare, contiguous above at their anterior (lower) borders. Clypeus brown, bearing six to ten brown hairs on each side. Proboscis brown, short, strongly chitinated. Palpi (fig. 24, *a*) darkish brown, long and slender; first segment rather larger and more distinct than usual, second and fourth subequal, about half the length of the third, third not at all inflated, without a sensory pit, but bearing sensory hairs on the inner aspect, fifth the longest, twice the length of the fourth, not dilated at its end. *Mouth-parts* strongly chitinated; mandibles highly chitinated, distal halves dark coloured and bearing on their inner margin

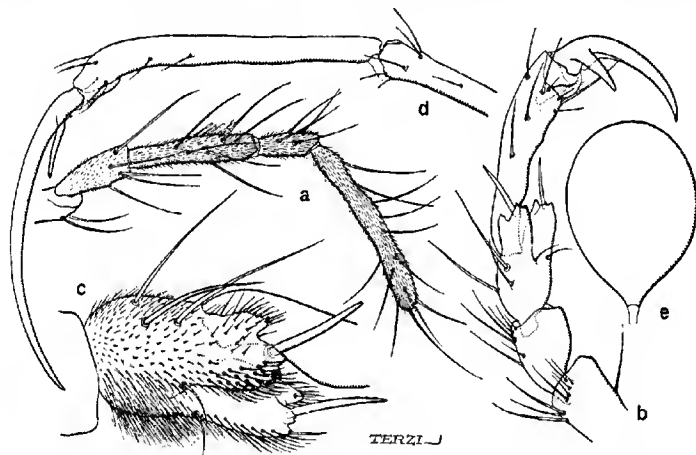


Fig. 24. *Tetrabezia argentea*, sp. n., ♀: *a*, palp; *b*, termination of fore leg; *c*, fourth tarsal segment more highly magnified; *d*, termination of hind leg; *e*, spermatheca.

eight or nine strong teeth. *Antennae* brown. First segment brown, small. Torus ochraceous, bearing a few short hairs. Third segment twice the length of the fourth, basal two-thirds pale brown, apical third darkish brown. Segments 4 to 10 with basal halves pale brown and apical halves darkish brown, more or less flask-shaped, subequal, about three times as long as broad. Segments 11 to 15 darkish brown with pale brown bases, more or less elongated; segments 11 and 12 about four and six times as long as broad respectively; segments 13 to 15 much longer, subequal, about fourteen times as long as broad; the last segment ending in a blunt point bearing a long seta. Hairs sparse, rather long. Segments 3 to 10 bearing long slender spines. *Thorax* uniformly brown with a greyish blue lustre, sparsely clothed with short hairs, and bearing dorsally at the middle of the anterior border a well-developed, pointed, pale brown spine (about 165 μ long) which is directed almost vertically. *Pleurae* rather dark brown. *Scutellum* uniformly dark brown, bearing two lateral and two centro-marginal bristles, which are short and stout, and numerous short

hairs. Post-scutellum dark brown. *Wings* (fig. 25) slightly infuscated at their tips and with a brownish patch near the middle of the anterior margin and over the region of the anterior cross-vein. Veins yellowish brown. Third vein and costa join close to the tip of the wing, not quite so close to it, however, as the distal end of the upper ramus of the fourth vein. Bifurcation of the fourth vein just proximal to the cross-vein, that of the fifth vein slightly more distal. Wing surface densely clothed with very minute microtrichia, but without macrotrichia. Halteres with pale brown stems and creamy-white knobs, bearing on each side of the bases of the knobs a row of four very small hairs. *Legs* brown, with infuscation on the hind femora, the knees, and over the whole of the third and fourth tarsal segments of the fore and middle legs, and the last four tarsal segments of the hind legs. Fore legs (fig. 24, *b*) with short femur, not appreciably swollen, bearing a few (two or four) short black spines on the apical third; tibia a little shorter than the femur, bearing a long, pale brown, apical spine; first tarsal segment more than twice as long as the second, but shorter than the tibia, second as long as the third and fourth together, third almost cordiform, fourth bilobed, each lobe produced ventrally into a process which has a bifid end and bears a strong black spine (fig. 24, *c*), fifth segment about as long as the second, not swollen. Middle legs with femur and tibia not swollen, longer than on the fore legs, unarmed except for apical spine on the tibia; first tarsal

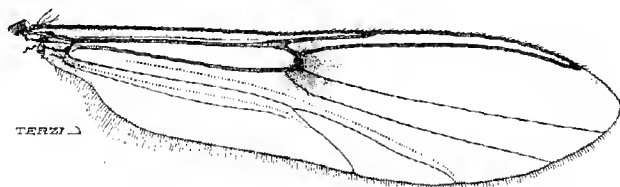


Fig. 25. *Tetrabezzia argentea*, sp. n., wing of ♀.

segment long, other segments as on the fore legs. Hind legs (fig. 24, *d*) with femur slightly swollen at its distal half, unarmed; tibia longer than the femur, tarsal segments all extremely long and cylindrical, in one instance measuring approximately 2.3 mm., 1.9 mm., 1.0 mm., 0.7 mm., and 0.8 mm., whereas the femur and tibia measured 2.6 mm. and 2.8 mm. respectively. Claws (fig. 24, *b*, *d*) long and unequal, fused basally, those on the fore and middle legs being the one almost as long as the fifth tarsal segment and the other about half this length, on the hind legs the one extremely long (but still about the same length as the fifth tarsal segment) and the other about one-fifth this length. Empodium rudimentary. *Abdomen* dark brown, with the dorsal surface silvery grey, especially on segments 2 to 6, which are almost entirely this colour, except for dark brown apical bands; posterior extremity and cerci white. The abdomen is petiolate. Spermathecae (fig. 24, *e*) two, highly chitinated, subspherical to oval, subequal, about 90 μ by 80 μ ; the commencement of the duct chitinated for only a short distance (about 7 μ).

NIGERIA (SOUTHERN PROVINCES): Yaba, near Lagos, 4.viii.1909 and 10.ix.1909, 2 ♂♂ (Dr. W. M. Graham). One specimen taken "hovering in the bush" and the other "hovering in the air at 2 p.m."

***Bezzia africana*, sp. n.**

Length of body (one female), 2.4 mm.; length of wing, 1.6 mm.; greatest breadth of wing, 0.6 mm.

A very dark brown or almost black midge, with pale brown tarsi. Head very dark brown or almost black, bearing dark brown hairs. Eyes bare, separated above. Clypeus dark brown, hairy. Proboscis dark brown, short, well chitinated.

Palpi dark brown, rather slender; first segment small, second and fourth subequal, about twice as long as broad, fifth slightly longer and pyriform, third cylindrical, not inflated, slightly longer than the fifth, without a definite sensory pit, but bearing a few long sensory hairs at the junction of its middle and distal thirds. *Antennae* dark brown; segments 3 to 10 slightly paler than the rest. First segment dark brown, small, bearing dorsally one or two dark brown hairs. Torus dark brown, bearing numerous dark brown hairs. Segments 4 to 10 dark brown apically, paler basally; oval, subequal, about twice as long as broad. Segments 11 to 15 dark brown except at their bases, elongated distally, their lengths ranging from nearly four times to about five times the breadth, the fifteenth segment being the longest and ending bluntly. Hairs short and scanty; segments 3 to 10 bearing also long slender spines. *Thorax* (fig. 26, *a*) very dark brown or almost black with silvery-grey markings, as shown in the diagram. Dorsum clothed with short, very dark brown hairs. *Pleurae* very dark brown. Scutellum dark brown, bearing two lateral and two centro-marginal

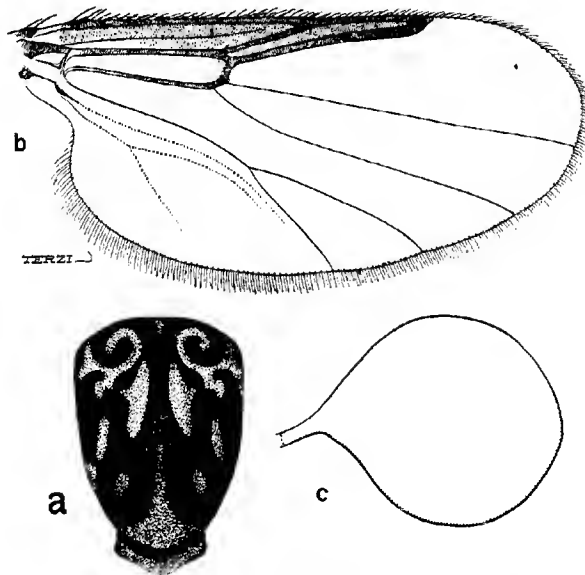


Fig. 26. *Bezzia africana*, sp. n., ♀: *a*, thoracic adornment (diagrammatic); *b*, wing; *c*, spermatheca.

bristles and numerous small hairs. Post-scutellum very dark brown. *Wings* (fig. 26, *b*) unspotted, but infuscated at the anterior margin, especially over the middle third. Third vein and costa joining about three-quarters of the length of the wing from the base, infuscated, especially at their distal ends. Fork of the fifth vein distal to the level of the anterior cross-vein. Wing surface densely clothed with microtrichia, but without macrotrichia. Halteres brown, with dark brown knobs, and bearing a few small hairs at the bases of the knobs. *Legs* femora and tibiae very dark brown, almost black, the fore leg with pale bands on each side of the knee and near the distal end of the tibia; tarsi pale brown, the first three segments infuscated at their apices, the fourth and fifth almost completely. Femora of the fore legs armed on their distal halves with three short, stout, black spines, other femora unarmed; first tarsal segment on all the legs about twice as long as the second,

fourth cordiform, fifth not armed with batonnets. Claws on all the legs short, less than half the length of the fifth tarsal segment, equal, simple. Empodium small, hair-like. Abdomen very dark brown or almost black dorsally, sparsely clothed with short, dark brown hairs, which are most abundant on the posterior segments. Cerci dark brown. Spermathecae (fig. 26, c) two, dark-coloured and densely chitinated, subspherical, but in the single specimen examined one was somewhat drawn out basally, subequal, about $85\ \mu$ by $70\ \mu$; commencement of the duct narrow, chitinated for a short distance (about $20\ \mu$).

SOUTH AFRICA: Mossel Bay, Cape Province, ii.1922, 1 ♀ (R. E. Turner).

Bezzia (Probezzia) mashonensis, sp. n.

Length of body (one female), 3.8 mm.; length of wing, 3.3 mm.; greatest breadth of wing, 1.0 mm.

Head dark brown, occiput clothed with dark brown hairs. Eyes bare, widely separated above. Clypeus dark brown. Proboscis dark brown, short, strongly chitinated. Palpi dark brown; first segment small, second shorter than the third, the latter not inflated, nearly four times as long as broad, and without a definite sensory cup but bearing near its distal end a number of sensory hairs, fourth segment

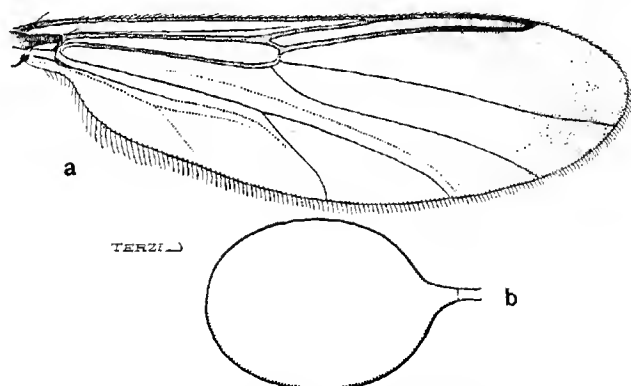


Fig. 27. *Bezzia (Probezzia) mashonensis*, sp. n., ♀: a, wing; b, spermatheca.

the shortest, less than half the length of the third, fifth a little longer (but shorter than the third) and slightly dilated at its end. Mouth-parts highly chitinated; mandibles bearing seven large, strong teeth. Antennae rather dark brown. First segment dark brown, small, bearing two small hairs. Torus yellowish brown, bearing a few short hairs. Third segment pale brown basally, dark brown apically. Segments 4 to 10 dark brown, from almost cylindrical to flask-shaped, length ranging from twice to three times the greatest breadth. Segments 11 to 15 dark brown, elongated, length ranging from six to nine times the breadth, the last segment being the longest and terminating bluntly. Hairs dark brown, short and scanty. Thorax uniformly dark brown, bearing a minute spine dorsally at the middle of the anterior border, clothed with short, dark brown hairs, and bearing laterally and posteriorly a few dark brown bristles. Pleurae dark brown. Scutellum uniformly brown, bearing two centro-marginal bristles, laterally on each side a transverse row of four bristles, and numerous small hairs. Post-scutellum very dark brown, bearing a few hairs. Wings (fig. 27, a) infuscated at their tips, and to a lesser extent over the distal third.

Venation of the usual type. The third vein joins the costa about seven-eighths of the length of the wing from the base. Fork of the fifth vein situated at almost the same level as the anterior cross-vein. Surface of the wing densely clothed with small microtrichia, but without macrotrichia. Fringe short. Halteres with greyish brown stems and dark brown knobs, bearing a few small hairs at the bases of the knobs. *Legs* pale brown, almost uniformly coloured except for infuscation on the knees (especially those of the middle and hind legs), at the apices of the first three and over the whole of the last two segments of the tarsi. Femora not inflated and without strong spines. Tibiae moderately hairy, fore and middle legs with a stout apical spine. Tarsus with first segment more than twice the length of the second on the middle and hind legs, rather shorter on the fore legs, fourth bell-shaped, fifth armed with stout, dark, spines—usually two on each side ventro-laterally, but sometimes one or three on one side. First two tarsal segments of the hind legs each with a double row of "bulbous" hairs, the third segment of the hind legs and the first, second, and third segments of the middle legs each with a single row. Claws equal, short, about half the length of the fifth tarsal segment, each with a small basal tooth. Empodium small, hair-like. *Abdomen* dark brown, rather paler ventrally than dorsally, clothed with dark brown hairs, which are most abundant on the posterior segments. Spermathecae (fig. 27, *b*) two, highly chitinated, oval to pyriform, unequal, measuring in the single specimen examined about $90\ \mu$ by $60\ \mu$ and $75\ \mu$ by $45\ \mu$ respectively; commencement of the duct chitinated for only a very short distance, and confluent with the base of the spermatheca.

MASHONALAND: Salisbury, iii.1900, 1 ♀ (*Dr. G. A. K. Marshall*).

Kieffer (1919) cites as one of the characters of his genus *Probezzia* that the fifth tarsal segment is unarmed in both sexes, but more recently (1921) he has described a species, *P. bakeri*, in which it is "Armé a tous les tarses de deux ou trois rangées longitudinales et ventrales de six batonnets noir presque deux fois aussi long que la grosseur de l'article," so that it is clear he no longer considers this character of generic value. We have therefore referred the species described above to the genus *Probezzia*.

ANOPHELES LARVAE FROM PALESTINE AND ELSEWHERE.

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The following notes are the outcome of an attempt to construct a key to the *Anopheles* larvae which occur in Palestine. The scope of the enquiry gradually extended itself to include certain species which occur in other parts of the world, but which have close affinities to the Palestinian species.

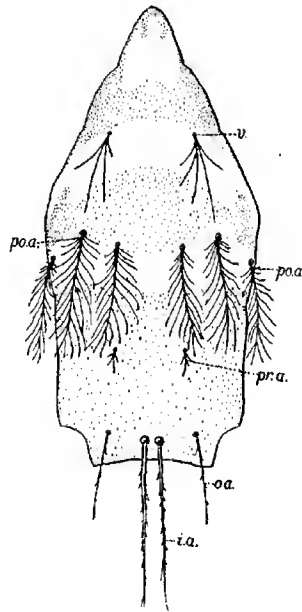


Fig. 1. *Anopheles algeriensis*, Theo., clypeus and vertex of fourth-stage larva: *i.a.*, inner anterior clypeal hair; *o.a.*, outer anterior clypeal hair; *po.a.*, post-antennal hairs; *pr.a.*, pre-antennal hair; *v.*, vertical hair.

The Larva of *Anopheles algeriensis* and its Relatives.

The larva of *Anopheles algeriensis* was described very shortly by E. & E. Sergeant, but their description was not sufficient to enable Edwards to include it in his key to the larvae of the species which occur in the Palaearctic Region. I have therefore drawn up this short description of the fourth-stage larva, comparing it especially with that of *A. bifurcatus* which has been dealt with in detail by Lang, and which is its closest ally in Palestine, and with specimens of the still more closely related *A. aitkeni*, Theo. My material of *A. algeriensis* consists of four last-stage skins of larvae from the marsh at Beisan, Palestine; individual larvae were isolated and identified by the imago which subsequently emerged. I have also examined larvae from Wadi Janzur,

near Jenin. For comparison, I have had larvae and skins of *A. bifurcatus* from Palestine and from two English localities (F. W. Edwards), and skins of *A. aitkeni* from the Federated Malay States (H. P. Hacker, in Brit. Mus.).

Head.—I cannot distinguish the antenna and palpi of *A. algeriensis* or *A. aitkeni* from those of *A. bifurcatus* (Lang, fig. 81). It will be remembered that Stanton described two types of chaetotaxy on the head of the larvae of *A. aitkeni*; in his type I the inner anterior clypeal hair is "long and stout; middle third with short lateral branches, elsewhere the shaft is bare." In type II the same hair is "long, basal third or stem stout and bare; at the end of the stem the hair branches into three to six divisions each equal to twice the length of the stem." James and Liston describe the hair as being "stout and bifurcated like the prongs of a pitchfork." It seems that several types exist. The specimens sent by Dr. Hacker to the British Museum all belong to Stanton's second type, which is unfortunate, as it is the first type that most clearly resembles the larva of *A. algeriensis*. In fact, so far as the setae of the head are concerned, the only differences which I can find between *A. aitkeni* (type I as figured and described by Stanton) and *A. algeriensis* (fig. 1) is that in the former the vertical ("inner occipital") hair has generally two branches, and in the latter it has four or five. For all practical purposes the two cannot be distinguished from one another by the chaetotaxy of the head, but from *A. bifurcatus* they differ in the following particulars:—

Hair.	<i>A. algeriensis</i> and <i>aitkeni</i> (I).	<i>A. bifurcatus</i> .
Inner anterior clypeal (<i>i.a.</i>).	Long and very stout, simple. With fine irregular feathering of the shaft. Occasional fine terminal branching.	Ditto, but feathering of shaft is absent.
Outer anterior clypeal (<i>o.a.</i>).	Fine and quite simple, or with fine feathering of shaft.	Without feathering of shaft. With occasional terminal branch.
Pre-antennal (<i>pr.a.</i>).	Very short and fine, divided from base into three or four branches.	Much longer, reaching base of anterior clypeal hairs, otherwise similar.
Vertical (<i>v.</i>).	Slender and short, divided at base into 4 or 5 branches (<i>algeriensis</i>) or two branches (<i>aitkeni</i>).	Simple and longer.

Thorax.—In the larvae of many species of *Anopheles* the inner shoulder hairs furnish points of distinction. In the species under discussion, and in many others, the innermost and second hairs are branched and the outer is minute and simple. The larvae of *A. algeriensis* and *bifurcatus* are indistinguishable. In that of *A. aitkeni* the innermost and second hairs are shorter but more branched than in the other species, but the difference is slight.

Abdomen.—Fully developed float-hairs are found on most of the abdominal segments of nearly all Anopheline larvae; on segments anterior to them one finds rudimentary structures which are no doubt serially homologous. These rudimentary float-hairs cause confusion because some authors reckon them as float-hairs and others disregard them. Let us define a "float-hair" as a structure composed of a stem upon which are articulated a number of flattened members—the leaflets. A "rudimentary float-hair" is similar in its position on the segment, but the members are either not articulated on the stem, or else not flattened, and they are generally less numerous than the leaflets on the float-hairs. Using the terms in this sense, one finds rudimentary float-hairs on the metathorax and first abdominal segment of the larva of *A. aitkeni* and *A. algeriensis*, and float-hairs on the second to the seventh abdominal segments, that on the second being smaller than the others. In *A. bifurcatus* rudimentary float-hairs are absent; the float-hairs are disposed as in the other two

species. The shape of the stalk of the float-hair is identical in the three species, but they may be distinguished by the structure of the leaflets. In *A. bifurcatus* (fig. 2, *b*) there are about sixteen leaflets, long and narrow and delicate; the teeth are shallow and few; there is no terminal filament. In *A. algeriensis* (fig. 2, *a*) there are about sixteen leaflets; they are short and wide and irregularly, though deeply toothed, and they have a short and ill-defined terminal filament. In *A. aitkeni* (fig. 2, *c*) the leaflets vary in number from 15 to 20, but they are generally 16 to 18; they are still broader than in *A. algeriensis*, and the teeth are still more numerous and more deeply cut, so that the transition from the wide part of the leaflet to the terminal filament is abrupt, and the filament though short is well-defined. These structures have been figured by James and Liston, but are here refigured for easy comparison. In the comb, as in so many other respects, *A. algeriensis* (fig. 3, *a*) and *A. aitkeni* resemble one another very closely, indeed I can detect no constant differences between them; in each there are some 14 to 16 teeth, of which seven are long; there is great difference in size between the

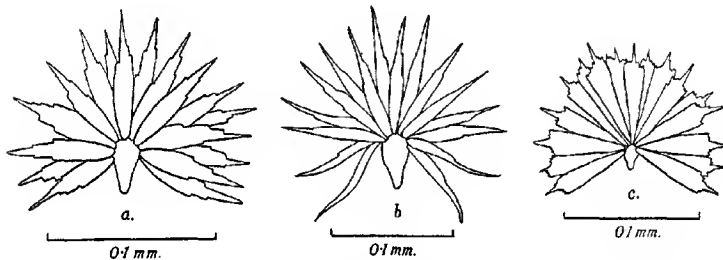


Fig. 2. Float-hairs of fourth-stage larva of (a) *Anopheles algeriensis*, Theo.; (b) *A. bifurcatus*, L.; (c) *A. aitkeni*, James.

long and short teeth, which are not at all regularly alternated. In *A. bifurcatus* (fig. 3, *b*), on the other hand, there are 20 to 25 teeth, of which about ten are long, and there is less difference in length between the long and the short, which alternate fairly regularly with one another. In the abdominal plates there are certain small but apparently constant differences, but as the other characters provide clear distinctions between the species, I have decided not to figure or describe the plates.

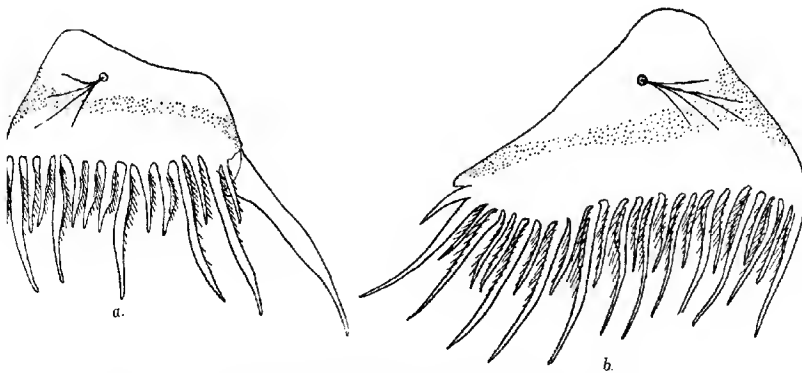


Fig. 3. Comb of eighth abdominal segment of fourth-stage larva of (a) *Anopheles algeriensis*; (b) *A. bifurcatus*.

Summary.—The mature larva of *Anopheles Algeriensis* is very similar to that of the closely related *A. aitheni*, from which it may be distinguished by the float-hairs (fig. 2). In the Palaearctic region it can only be confounded with the larva of *A. bifurcatus*; the two differ in the pre-antennal and vertical hairs, the disposition and shape of the float-hairs, and very greatly in the comb on the eighth abdominal segment.

The Fourth-stage Larva of *Anopheles sergenti* and certain other Species.

The work which is here described was originally undertaken in order to find reliable points by which the larvae of *Anopheles sergenti*, Theo., and *A. superpictus*, Grassi, both of which occur in Palestine, could be separated. Mr. F. W. Edwards suggested that the scope of the enquiry should be extended to include certain other species of the subgenus *Myzomyia*, and that attention should be given not only to the structures which are generally used to distinguish between different species of larvae, but also to the markings on the head, and to the dorsal plates. It appeared probable that attention had been too narrowly focused on such points as float-hairs and combs, and that by searching for points of difference on other parts of the body we might be able to distinguish between species which are at present regarded as inseparable in the larval stage. In fact, I began to look for points of difference between species not because they ever occurred together in nature, but because they were believed to be nearly related.

I have studied numbers of *Anopheles sergenti* from Palestine and Tunisia (coll. Dr. M. Langeron, in the British Museum), *A. superpictus* from Quetta in Baluchistan and from Palestine, *A. aconitus*, Dön. (skins only) from the Federated Malay States (coll. Dr. H. P. Hacker, in the British Museum), and two specimens of *A. funestus*, Giles. It is to be regretted that I have been unable to obtain any material of *A. culicifacies*, Giles, for comparison with *A. sergenti*, or of *A. listoni* for comparison with *A. funestus*. The description of *A. culicifacies* and *A. listoni* in James & Liston and in Stephens & Christophers are no doubt sufficient to distinguish these species from their Indian congeners, but are insufficient for my purpose.

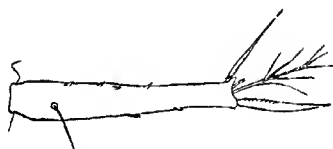


Fig. 4. *Anopheles sergenti*, Theo., left antenna of fourth-stage larva, seen from above.



Fig. 5.—*Anopheles sergenti*, Theo., right palp of fourth-stage larva, from above.

I have carefully examined fourth-stage larvae of the four species organ by organ and find the following points of interest:—

Head.—The antennae and palps of the four species seem to be indistinguishable. Those of *A. sergenti* are figured for comparison with those of other groups of *Anopheles*. The antenna (fig. 4) bears a short simple hair which arises on the upper side of the shaft near the base. The lower side of the shaft is spiny, and possibly this character is rather more strongly developed in *A. funestus* than in the other species. The tip of the antenna is armed with two spines, of which the median is the larger; between them arises a long compound hair and a short blunt bristle. The palp (fig. 5) bears a large hair with three main branches, each of which in turn is branched to the second degree.

On the lateral aspect of the extremity there are two stout spines and two thin lamellae; median to these arises a fan-shaped lamella, on the surface of which are two short blunt spines.

The general type of the chaetotaxy of the head is shown in figure 6, and has already been figured and described for *A. aconitus* by Stanton, and for *A. superpictus* by Edwards. *A. superpictus*, *sergenti* and *funestus* are extremely similar, the only point of difference being a very slight feathering of the shaft of the inner anterior clypeal hair (*i.a.*), absent in *A. funestus* and *sergenti*, but present in *A. superpictus*; this feathering is so fine and slight that it apparently escaped the notice of Edwards, and it is mainly of interest because it leads up to the more conspicuous feathering of *A. aconitus*. *A. aconitus* differs also from the other three species in the pre-antennal (*pr.a.*) and vertical (*v.*) hairs, both of which are shorter and have about six branches.

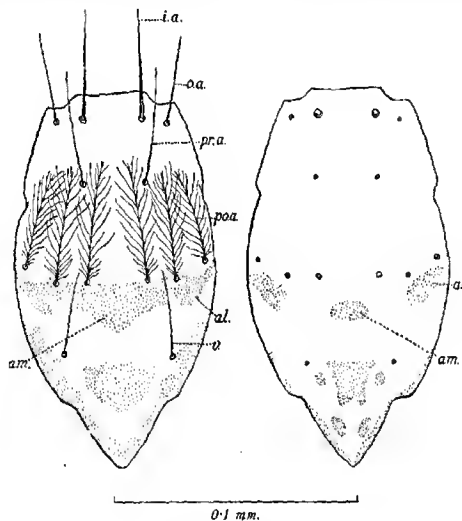


Fig. 6. Clypeus and vertex of *Anopheles sergenti* (left) and *A. superpictus* (right); *al.*, *am.*, anterior lateral and medium dark areas; *i.a.*, *o.a.*, inner and outer anterior clypeal hairs; *po.a.*, *pr.a.*, post- and pre-antennal hairs; *v.*, vertical hair.

A useful point of distinction between *A. sergenti* and *A. superpictus* is to be found in the dark marking of the vertex. As will be seen by referring to figure 6, in *A. superpictus* (right), the anterior set of markings are represented by three small patches, two lateral (*al.*) and one (*am.*) small and medial; in *A. sergenti* (fig. 6, left), *aconitus* and *funestus* the three coalesce into a broad butterfly-shaped band. This character is liable to slight variation, but appears to be of great value as a point of discrimination. The markings on the posterior part of the vertex are so variable in both species that they are valueless.

Thorax.—The shoulder hairs of the four species exhibit no points of difference. The "thick feathered hairs springing from a chitinous pocket near the middle of the thorax," which is useful in identifying *A. funestus* in the field in Zanzibar (Mansfield-Aders), is well-developed in all the species here discussed. The presence or absence of a float-hair on the metathorax will be dealt with below.

Abdomen.—When one studies the metameric distribution of the float-hairs of these larvae it is interesting to find that *A. sergenti* (fig. 7), *aconitus* and *funestus* resemble one another closely and differ very widely from *A. superpictus* (fig. 8). In the first three species, as Langeron has already described in the case of *A. sergenti*, rudimentary float-hairs, in the sense in which the term has been already defined, are present on the metathorax (fig. 7, c), small float-hairs with a dozen leaflets on the first abdominal segment (fig. 7, a), and float-hairs with about 18 to 20 leaflets on the segments 2-7 (fig. 7, b). The larvae of *A. listoni* and *A. culicifacies*, as described and figured by James & Liston, evidently fall into the same group.

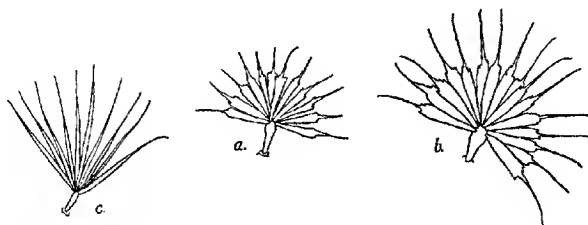


Fig. 7. Float-hairs of fourth-stage larva of *Anopheles sergenti*: a, on first abdominal segment; b, on second abdominal segment; c, on metathorax.

In *A. superpictus*, on the other hand, there is no rudiment on the metathorax or first abdominal segment, a small float-hair on the second segment (fig. 8, b) and full-sized ones (fig. 8, c) on segments 3-7. It is probable that the metameric distribution of the float-hairs provide a clue to the affinities of the species of *Anopheles*, for one can hardly suppose that the presence or absence of so complex an organ as a float-hair would be evolved on many separate occasions on any particular segment. The four species under examination exhibit no striking differences either in the number of leaflets, which vary from 16 to 19, and exceptionally reach 21-22, or in their shape. Those of *A. funestus* and *A. aconitus* are, perhaps, a little more definitely shouldered than those of the other two species.

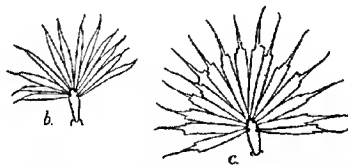


Fig. 8. Float-hairs of fourth-stage larva of *Anopheles superpictus*: b, on second abdominal segment; c, on third abdominal segment.

On the dorsum of every abdominal segment of such a species as *A. sergenti* there are two chitinous plates, the anterior larger than the posterior. As the anterior plates furnish a ready means of distinguishing between the species, even with a hand-lens, I have neglected the posterior plates; probably they may prove of use in discriminating between other species, but that is beyond the scope of this paper. In *A. sergenti* (fig. 9, a) the plates are all as wide as, or wider than, the gut; they increase regularly in size from the first to the eighth, and are (except the first and eighth) convex anteriorly and straight posteriorly. In *A. superpictus* (fig. 9, b) the anterior plate of each segment is distinctly narrower than the gut; the first is triangular, the others are

all biconvex, the second being the narrowest and the eighth the widest. In *A. funestus* (fig. 9, c) and *aconitus* (fig. 9, d) the plates are much wider than the gut, and cover nearly the whole width of the abdomen. Posterior plates appear to be absent. In *A. funestus* all the plates are somewhat rectangular in shape, the first three with the posterior margin excavated. The photograph of the larval skin of *A. funestus* var. *arabica*, published by Christophers & Khazan Chand, suggests that in this variety the plates are less rectangular than in my specimens. In *A. aconitus* all the plates (except the eighth) are inclined to be semilunar in shape, with the posterior margin quite evenly curved.

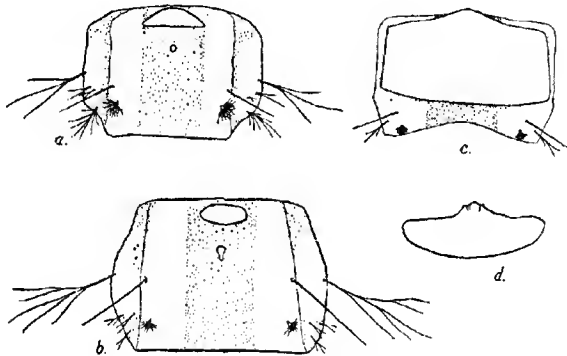


Fig. 9. Fourth abdominal segments of fourth-stage larvae of (a) *Anopheles sergenti*, (b) *A. superpictus*, (c) *A. funestus*, seen from above, the median dotted area representing the gut full of food; (d) dorsal plate only of *A. aconitus*. It is probable that the differences in shape of the segment are due to preservation and mounting.

The comb on the eighth segment, which has been already figured by Langeron in the case of *A. sergenti*, is of no use in separating the four species. In each of them the number of teeth varies between 11 and 15, but is commonly 12 or 13; the teeth are of various sizes, which intergrade with one another; the hair which is associated with the comb has from 6 to 8 branches.

Summary.—The fourth stage larvae of *A. superpictus*, *sergenti*, *funestus* and *aconitus* are discussed. *A. superpictus* may be at once separated from the others by the absence of float-hairs, or rudiments of float-hairs, from the metathorax and first abdominal segment; also by the small extent of the dark markings on the head, and the narrowness of the dorsal plates of the abdomen. *A. sergenti* differs from *A. aconitus* and *funestus* (of which Edwards has suggested that it might be regarded as a variety) principally in the abdominal plates. *A. aconitus* and *A. funestus* differ from one another in details connected with the inner anterior clypeal (*i.a.*) pre-antennal (*pr.a.*) and vertical (*v.*) hairs, and in the shape of the abdominal plates, but they are evidently closely related, if larval anatomy is any evidence of relationship.

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A NEW AUSTRALIAN PHLEBOTOMUS (DIPT., PSYCHODIDAE).

By GERALD F. HILL.

The discovery of a species of *Phlebotomus* in Australia is of considerable interest in view of the fact that the genus contains several exotic species known to be the vectors of specific fevers in man (verruca, pappataci fever, etc.).

The occurrence of some undetermined fevers in North Australia naturally suggests the possibility of Dipterous intermediaries occurring amongst the numerous species of CHIRONOMIDAE, PSYCHODIDAE and SIMULIIDAE, but so far no evidence has been obtained to incriminate any of these flies. The first-mentioned family is represented in North Australia by a considerable number of undetermined and apparently undescribed species with pronounced blood-sucking habits. Taylor (1915) has recorded one species of PSYCHODIDAE (*Pericoma townsvillensis*, Taylor) as a biting fly; but this record requires confirmation, since there is some doubt as to whether this species, or any other PSYCHODINAE, possesses mouth-parts capable of piercing the skin. Several undescribed species of SIMULIIDAE occur in tropical Australia, but all of them appear to live upon the blood of Lepidopterous larvae and not upon mammalian blood. The species described in this paper has well-developed biting mouth-parts in both sexes, and is, therefore, a potential disease-carrier.

The Medical Journal of Australia (1921, p. 193) contains a reference to a species of *Phlebotomus* discovered at Port Moresby, Papua, by Dr. W. M. Strong, and forwarded to the United States of America by Dr. Lambert, of the Hookworm Campaign, for report. I can find no further reference to this or to any other species from the Australian Region in the literature at my disposal. During a recent visit to Papua, Dr. Strong placed his collection at my disposal and also searched for fresh specimens, but further examples were not secured. However, since my return to Townsville, Dr. Strong found (July) a female specimen, which he kindly forwarded to me for examination. Although very closely allied to the Queensland species, the antennae of the Papuan specimen show a marked specific difference, which, doubtless, will be further emphasised when male genitalia are available for comparison.

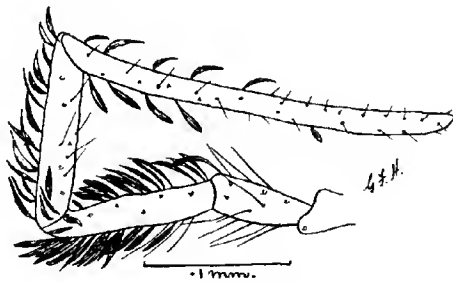


Fig. 1. *Phlebotomus queenslandi*, sp. n., palpus of ♂.

***Phlebotomus queenslandi*, sp. n.**

♂. Body uniform light horn-colour, legs darker, wings with brassy iridescence in some lights.

Head, thorax and abdomen clothed with long (0.176 mm.) curved hairs, shortest and densest on the clypeus; pleura with shorter and straighter hairs and scattered,

long, moderately broad, mosquito-like scales, variable in shape, but generally about one-fifth as wide as long, lanceolate, with pointed or truncate apex; proboscis stout, about twice as long as clypeus, with scales on lower surface; clypeus moderately convex; eyes very large and coarsely faceted; halteres clothed with minute scales; palpi (fig. 1) with first joint very short, second about two-thirds longer, with scattered hairs, third and fourth equal in length, with scattered hairs and numerous long scales; fifth more than twice as long as third and fourth together, with scattered hairs and fewer scales; all the joints with minute (?) sensory hairs; antennae (figs. 2, 3) 16-jointed, joints 4 to 13 five-sevenths as long as the third, joints 14 to 16 three-sevenths as long as third.

Wings (fig. 4) long and slender, pointed at the apex, about one-fourth as wide as long, the margin and veins densely clothed with long curved hairs, membrane with many microtrichia.

Legs long and slender, densely clothed with small scales and bearing a few long hairs, coxae with long hairs similar to those on pleurae.

Abdomen with six segments distinct, densely clothed with long hairs like those on thorax. Genitalia as in figure 5.

♀ (fig. 6). Similar to male.

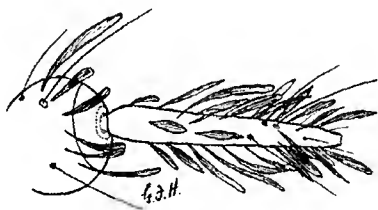


Fig. 2. Second and third joints of antenna.

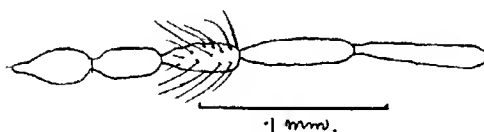


Fig. 3. Terminal joints of antenna.

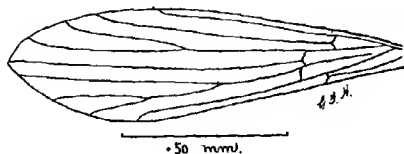


Fig. 4. Wing of *Phlebotomus queenslandi*.

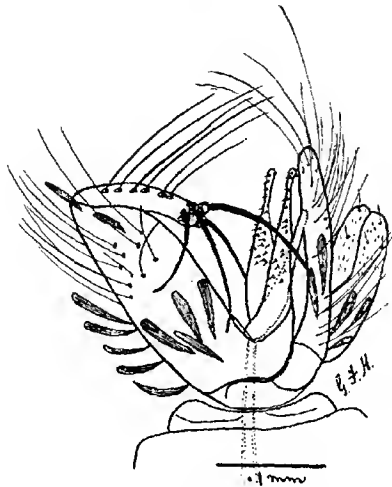


Fig. 5. Genitalia of ♂ (one superior clasper not shown).

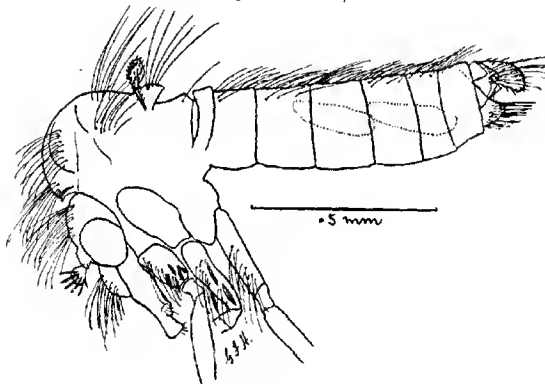


Fig. 6. *Phlebotomus queenslandi*, sp. n., ♀, lateral view.

Measurements :—

	♂	♀
Length from anteriormost part of mesonotum to apex of genitalia	1.780	1.500
Length from posterior margin of head to apex of labium	0.464	0.517
Head, at and including eyes, width	—	0.282
Proboscis, from apex of clypeus, length	0.160	0.176
Eyes, longitudinal diameter	0.144	0.176
" vertical diameter	0.112	0.128
Antennae, length	0.90	1.00
" 3rd joint	0.112	0.128
" 4th-13th	0.080	0.080
" 14th-16th (about)	0.048	0.048

(Note.—In the Papuan species the 3rd joint is 0.256 long and the 4th 0.112 long.)

Wings, ♂, length 1.300, width 0.325.

Wings, ♀, " 1.450, " 0.362.

Legs, length :

						♂	♀
						mm.	mm.
fore femora	..	..	..	..	..	0.560	0.464
mid "	..	..	..	..	..	0.544	0.464
hind "	..	..	..	..	..	0.672	0.512
fore tibiae	..	..	..	..	..	0.480	0.400
mid "	..	..	..	..	..	0.593	0.512
hind "	..	..	..	..	..	0.832	0.672
fore tarsi : 1st joint	..	..	..	..	..	0.256	0.224
2nd "	..	..	..	..	..	0.160	0.128
3rd "	..	..	..	..	..	0.112	0.096
4th "	..	..	..	..	..	0.080	0.080
5th "	..	..	..	..	..	0.064	0.064
mid tarsi : 1st joint	..	..	..	..	..	0.320	0.224
2nd "	..	..	..	..	..	0.192	0.128
3rd "	..	..	..	..	..	0.112	0.096
4th "	..	..	..	..	..	0.080	0.080
5th "	..	..	..	..	..	0.064	0.064
hind tarsi : 1st joint	..	..	..	..	..	0.384	0.352
2nd "	..	..	..	..	..	0.208	0.192
3rd "	..	..	..	..	..	0.128	0.112
4th "	..	..	..	..	..	0.112	0.096
5th "	..	..	..	..	..	0.064	0.064

NORTH QUEENSLAND : Townsville, 11-14.1.1923.

Described from four males and four females ; types (♂ and ♀) in the National Museum, Melbourne ; paratypes in the British Museum, Australian Institute of Tropical Medicine, and the author's collection.

These flies were captured during the wet season at dusk on a bathroom window in one of the highest residential areas of the town. The floor of the room is lead-covered and drains into a grating in one corner, thence, by a piece of galvanised-iron down-pipe, into an open concrete drain. Owing to inequalities of the surface and frequent use of the shower, the floor is generally wet behind and under the bath, affording a possible breeding-place, were it not for a weekly scouring with strong disinfectant. Other open concrete drains, as well as a fernery, exist in the near vicinity. Except for the occupants of the house and a few cats and rats, there are no mammalian hosts near by. A horse is turned out at night in an adjoining paddock and a colony of large lizards occupies crevices amongst the rocks about twenty yards distant from the bathroom. The human occupants of the house are sometimes bitten at night by undetected insects, hitherto supposed to be *Culicoides*, of which two species have been captured on the bathroom window, but in a locality where the more severe bites of *Stegomyia fasciata*, F., and *Ochlerotatus vigilax*, Sk., are a very common occurrence, little notice is taken of minor pests. That the writer resided in Townsville for nearly four years without finding *Phlebotomus* may possibly be due to the fact that other residences did not contain such favourable collecting places for these flies.

OBSERVATIONS ON THE COCCIDAE OF THE MADEIRA ISLANDS.

By E. ERNEST GREEN, F.E.S., F.Z.S.

The following notes are based, chiefly, on a collection of COCCIDAE, gathered by Prof. T. D. A. Cockerell and Mr. A. C. de Noronha during the winter of 1920-21.

The fauna of an oceanic island is always of special interest. The Madeira Islands, consisting of Madeira, Porto Santo, and three uninhabited rocky islets, have a total area of 314 square miles. They lie about 440 miles west of Africa, at a latitude of between 32° and 33° N., and longitude of about 17° W.

Mrs. Fernald's Catalogue* and the Supplements issued by the U.S. Bureau of Entomology provide eight records only from Madeira, to which Lindinger† adds thirteen more names. Apart from these, I know of no other references to COCCIDAE from the Madeiras. The collections of Prof. Cockerell and Mr. Noronha now raise the number to 46 species, of which 37 appear in the present collection, including six new species that are here described for the first time. It will be observed that there are several unexpected absentees from the list. It is rather surprising, for instance, to find such widely distributed species as *Icerya aegyptiaca* and *Chrysomphalus ficus* unrepresented in these subtropical Islands.

A Catalogue of the Coccidae of Madeira.

(An asterisk indicates species included in the collection submitted by Prof. Cockerell and Mr. Noronha.)

- 1.**Icerya purchasi*, Mask.
On *Rosa*, *Pinus* and *Foeniculum vulgare*. Funchal; Pico San Martinho.
2. *Icerya seychellarum*, Westw.
On sugar-cane.
- 3.**Orthezia insignis*, Dougl.
On *Thunbergia* sp. and *Duranta plumieri*. Funchal.
- 4.**Ortheziola vejdoskyi*, Sulc.
At roots of grass. Portella Pass.

The discovery of this peculiar species (hitherto recorded from Bohemia and the British Isles alone) on an oceanic island is interesting. Prof. Cockerell suggests that the insects may have been transported on the feet of migratory birds. Another possible explanation is that they may have arrived in the crevices of drift wood.

- 5.**Asterolecanium thesii*, Dougl.
On *Phagnalon saxatile*. Pico San Martinho.
- 6.**Asterolecanium variolosum*, Ratz.
On *Quercus* sp. Funchal.
7. *Asterolecanium rehi*, Rübs.
On *Globularia salicina*.
8. *Asterolecanium fimbriatum*, Fonsc.
Recorded, by Lindinger, from *Genista* sp.
It should be noted that Lindinger regards *variolosum*, *thesii* and *rehi* as synonyms of *fimbriatum*.
9. **Eriococcus araucariae*, Mask.
On *Araucaria* sp. San Roques.

* A Catalogue of the Coccidae of the World, 1903.

† Die Schildläuse, Stuttgart, 1912.

- 10.**Dactylopius coccus*, Costa.
On *Opuntia tuna*. Funchal.
This is, doubtless, an introduction from the Canary Islands, where the insect was formerly under cultivation.
- 11.**Phenacoccus latipes*, sp. n.
Under stones, at roots of grasses. Funchal; Porto Santo.
- 12.**Phenacoccus madeirensis*, sp. n.
On *Hibiscus rosa-sinensis*, *Sida* sp., and *Acalypha* sp. Funchal.
- 13.**Pseudococcus citri*, Risso.
On *Anona cherimolia*, *Musa* sp., and *Achyranthes aspera*. Funchal; Ribera d. Santa Luzia.
- 14.**Pseudococcus longispinus*, Targ.
On *Dracaena* sp., *Ficus carica* and *Myoporum* sp. Funchal; Porto Santo.
- 15.**Pseudococcus sacchari*, Ckll.
On sugar-cane. Funchal.
- 16.**Pseudococcus heterospinus*, sp. n.
At the roots of grasses. Machico.
- 17.**Pseudococcus artemisiae*, sp. n.
At the roots of *Artemisia argentea*. Porto Santo.
- 18.**Pulvinaria grahami*, Ckll.
On *Nicotiana glauca* and *Lantana* sp. Funchal.
A close comparison of this species with *Pulv. antigoni*, Green, proves that the two are identical and necessitates the sinking of the latter name.
19. *Protopulvinaria pyriformis*, Ckll.
On *Lonicera* sp.
- 20.**Lecanium hemisphaericum*, Targ.
On *Mangifera indica*, *Cycas revoluta*, *Jossinia tinifolia*, *Myoporum* sp., *Asparagus sprengeri*, *Anona cherimolia*, and *Musa* sp. Funchal; Porto Santo.
- 21.**Lecanium hesperidum*, L.
On *Citrus limonium*, *Myoporum* sp., *Pilea* sp., *Muehlenbeckia* sp., and *Eriobotrya*. Funchal; San Roques; Porto Santo.
- 22.**Lecanium oleae*, Bern.
On *Nerium oleander*. Funchal.
- 23.**Lecanium nigrum*, Nietn.
On *Anona cherimolia*. Funchal.
- 24.**Lecanium nigrum-depressum*, Dougl.
On *Musa* sp. Funchal.
This variety is characterised by its depressed form and reddish brown colour.
- 25.**Lecanium cerei*, sp. n.
On *Cereus triangularis*. Funchal.
- 26.**Ceroplastes sinensis*, del Guer.
On *Streptosolen* sp. and *Duranta plumieri*. Funchal.
- 27.**Ceroplastes floridensis*, Comst.
On *Mangifera indica* and *Buxus sempervirens*. Funchal.
- 28.**Ceroplastes denudatus*, Ckll.
On *Ficus carica*. Funchal.
- 29.**Diaspis echinocacti*, Bouché.
On *Opuntia tuna*. "Cliffs west of Funchal"; Porto Santo.
- 30.**Diaspis boisduvali*, Sign.
On orchid. Funchal.

- 31.* *Diaspis zamiae*, Morg.
On *Cycas revoluta*. Funchal.
- 32.* *Diaspis rosae*, Bouché.
On *Rosa* sp. and *Rubus fruticosus*. Funchal ; Pico San Martinho.
33. *Diaspis visci*, Schr. *
On *Juniperus* spp.
- 34.* *Aspidiotus hederae*, Vall.
On *Tacsonia manicata*, *Nerium oleander*, *Euphorbia* sp., *Ruta graveolens*, *Sarothamnus scoparius*, *Asparagus sprengeri*, and *Vitis* sp. Funchal ; Porto Santo ; Pico San Martinho ; San Antonio.
- 35.* *Aspidiotus lataniae*, Sign.
On *Ficus carica*, *Foeniculum vulgare*, *Robinia pseudacacia*, *Vitis vinifera*, *Musa* sp., *Pyrus*, *Eriobotrya*, and *Psidium guyava*. Funchal ; Pico San Martinho ; San Roques.
- 36.* *Aspidiotus camelliae*, Sign.
On *Myoporum* sp. Porto Santo.
37. *Aspidiotus palmarum*, Morg. & Ckll.
On *Lonicera* sp.
38. *Aspidiotus maderensis*, Ldgr.
On *Juniperus cedrus*.
39. *Chrysomphalus aurantii*, Mask.
On *Cydonia vulgaris*.
- 40.* *Chrysomphalus dictyospermi*, Morg.
On palms, *Musa cavendishi*, *Phoenix* sp., *Buxus sempervirens*, *Rosa* spp., *Sarothamnus scoparius*, *Asparagus sprengeri*, and *Cinnamomum camphora*. Funchal ; Pico San Martinho ; San Antonio.
- 41.* *Chrysomphalus pinnulifera*, Mask.
On *Hedera* sp. Funchal.
- 42.* *Chrysomphalus pinnulifera* var. *diversicolor*, n.
On *Phoenix canariensis* and *P. dactylifera*, *Dracaena* sp., *Citrus*, *Buxus sempervirens*, *Musa cavendishi*, *Psidium littorale*, and *Asparagus* sp. Funchal ; Porto Santo.
- 43.* *Targionia laurina*, Ldgr.
On *Laurus canariensis* and *Ocotea foetens*. Funchal.
44. *Cryptophylaspis bornmülleri*, Rübs.
On *Globularia salicina*.
- 45.* *Fiorinia fioriniae*, Targ.
On *Buxus sempervirens*. Funchal.
- 46.* *Lepidosaphes beckii*, Newm.
On lemon and orange trees. Funchal ; San Roques.

Phenacoccus latipes, sp. n. (fig. 1).

Adult female of normal form. Living insect pale green ; the colour more or less masked by a thin covering of white powdery secretion. Subsequently concealed beneath a loose, woolly ovisac, which (in the type example) was of a hemispherical form. Other examples had constructed more compact, elongate ovisacs.

Antennae (c) relatively short ; 9-jointed, the division between 8th and 9th less sharply defined than those separating the other joints ; 2nd and 9th longest, approximately equal ; 3rd slightly shorter than 2nd ; 4th to 8th shortest, approximately equal. Limbs relatively small, but rather stout ; especially the third pair (d), of which the tibiae are markedly dilated. No conspicuous translucent pores on any part of the hind limbs. Claws with a denticle on the inner edge, at about one-third from the

extremity. Caudal lobes broadly rounded, moderately prominent. Caudal setae stout; longer than those of the anal ring. Ceriferous tracts weakly differentiated and rather difficult to locate; fifteen (or sixteen) pairs, each with two (or one) spines; the spines (*a b*) slender, often setiform. Body setae (*e*) rather stout, varying in size, often scarcely distinguishable from the cerarial spines. Trilocular pores numerous and conspicuous; evenly distributed, not concentrated on the ceriferous tracts. Discoid pores (*f*) unusually numerous; in crowded transverse series across the abdominal segments. Anterior and posterior dorsal osteoles conspicuous. A single, widely lunate, ventral osteole situated between the 2nd and 3rd abdominal segments. Length 2.5 mm.; breadth 1.75 mm.

Adult male said to be "raspberry pink."

"On underside of rocks on grass." Porto Santo.

The distinguishing characters of this species are the strongly dilated hind tibiae; the very slender, almost setiform, cerarial spines, and the crowded transverse series of discoid pores.

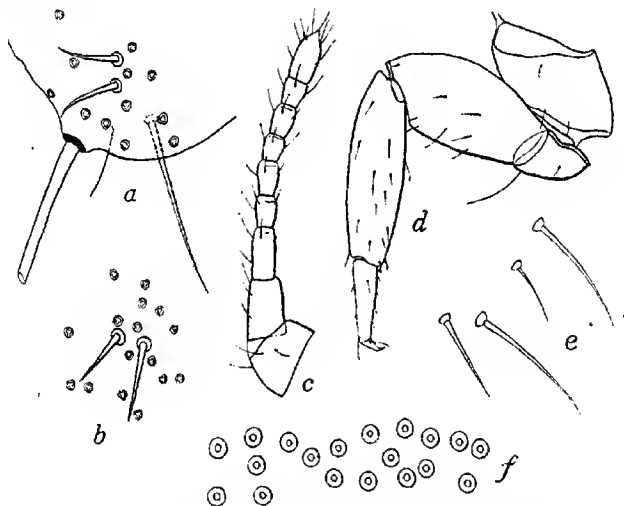


Fig. 1. *Phenacoccus latipes*, sp. n.: *a*, caudal lobe and ceriferous tract, $\times 450$; *b*, ceriferous tract, 2nd abdominal segment, $\times 450$; *c*, antenna, $\times 130$; *d*, hind limb, $\times 130$; *e*, body setae, $\times 450$; *f*, abdominal series of discoid pores, $\times 450$.

***Phenacoccus madeirensis*, sp. n. (fig. 2).**

Living insect pale green, dusted with white mealy secretion. Ovisac loose, white, of irregular form.

Antennae slender; 9-jointed; 2, 3, and 9 longest, approximately equal; 4, 5, and 6 next longest, approximately equal; 8 shortest. Limbs well-developed, long and slender; tarsus of first leg half the length of the tibia; tarsi of mid and third legs less than half as long as the respective tibiae. Claw (*b*) slender, with a conspicuous denticle on the inner edge, near the distal extremity. Ungual digitules slightly dilated at extremity; tarsal digitules slender, simple. Labium (*c*) narrow, approximately twice as long as its breadth across the base. Cerarii distinct; eighteen on each side; the 18th (caudal tract) with from three to five spines; the 3rd and 17th usually with

three; the remainder usually with two only, though an additional spine is occasionally present on the 2nd and 4th tracts. All the spines rather slender and acutely pointed, those on the caudal tract slightly longer than the others. Cerarial pores few (six to seven), except on the caudal tract, where they are more closely clustered. There are no cerarial setae on any but the caudal tract. Caudal setae longer (by about one-quarter) than those of the anal ring. Some longish, stout setae distributed sparsely on the venter, but more pronounced and clustered on the frons. Trilocular and discoid pores numerous, the latter in transverse series across the abdominal segments. Dorsal osteoles inconspicuous. A large and conspicuous oblate ventral osteole, its lower border irregularly trilobed. Length 2 to 3.5 mm.

On *Hibiscus rosa-sinensis*, *Sida* sp., and *Acalypha* sp. Funchal.

Differs from *Ph. aceris* in the relative size and proportions of the labium and limbs (cf. *a* with *d*, and *c* with *f*).

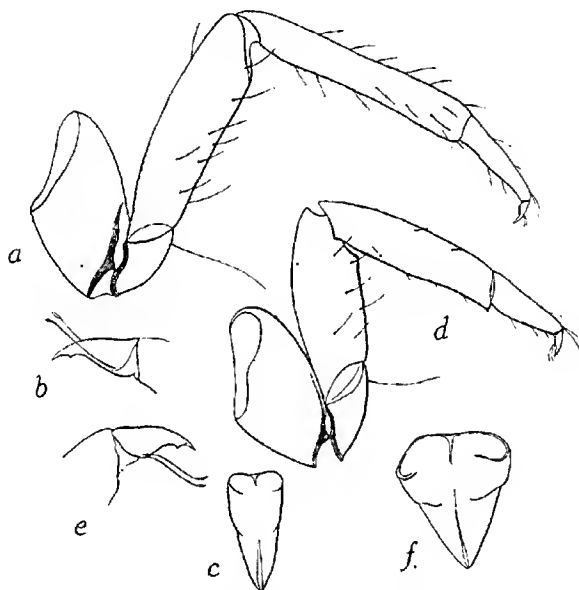


Fig. 2. *Phenacoccus madeirensis*, sp. n.: *a*, third leg, $\times 130$; *b*, claw of mid leg, $\times 450$; *c*, labium, $\times 130$.

Phenacoccus aceris, Sign.: *d*, third leg, $\times 130$; *e*, claw of mid leg, $\times 450$; *f*, labium, $\times 130$.

***Pseudococcus heterospinus*, sp. n. (fig. 3).**

Form long-ovate. Length 3.5 mm.; breadth 1.5 to 1.75 mm.

Antenna (*a*) 8-jointed; 2 and 8 elongate, 3 to 7 approximately as broad as they are long. Labium (*c*) conspicuously biarticulate; bluntly pointed; longer than broad. Limbs well-developed; robust. Tarsus less than or not more than half the length of the tibia. Some minute and inconspicuous translucent pores on the outer side of the hind coxae. Claw (*b*) without denticle. Tarsal digitules slender, minutely knobbed at

extremity. Ungual digitules slender; very slightly dilated towards extremity. Spiracles of normal form; the posterior markedly larger than the anterior pair. Cerarii present on the abdominal segments only; six on each side. Each tract with two spines, except the uppermost, which usually carries one only; those on the caudal tract (g) very large; those on the penultimate tract smaller; the remainder (e) minute. Caudal tract not markedly denser than the surrounding area. Cerarial pores in rather close clusters, especially on the posterior tracts. Dorsal osteoles well-defined (in mature examples). A conspicuous, oblate, medio-ventral osteole near the base of the abdomen. Caudal setae stouter, but scarcely longer than those of the anal ring (cf. h and i). Body setae moderately numerous, longish; more crowded on frons. Dermal pores (d) of two forms; the discoid form in transverse series, on two or three posterior segments only; small, obscurely trilocular pores numerous and distributed over the whole body.

On roots of grasses. Machico.

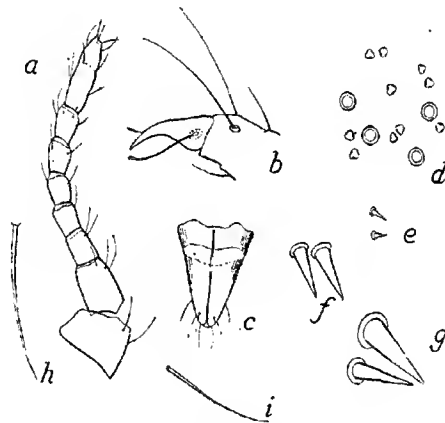


Fig. 3. *Pseudococcus heterospinus*, sp. n.: a, antenna, $\times 130$; b, foot of mid leg, $\times 450$; c, labium, $\times 130$; d, dermal pores (from abdomen), $\times 450$; e, f, g, cerarial spines (from antepenultimate, penultimate and terminal segments, respectively), $\times 450$; h, caudal seta, $\times 130$; i, seta from anal ring, $\times 130$.

***Pseudococcus artemisiae*, sp. n. (fig.4).**

Colour of living insect "pale green, with a very short fringe" of waxy tassels. Form long-ovate. Length 2 to 2.5 mm.; breadth 1 to 1.5 mm.

Antenna (a) 8-jointed; 2, 3, and 8 elongate, 4 to 7 approximately as broad as they are long. Labium (b) rather acutely pointed; biarticulate; longer than broad. Limbs well-developed, moderately robust. Tarsus slightly longer than half the tibia. Claw (d) without denticle. Tarsal digitules slender; one usually shorter than the other; the longer one with a minute terminal knob. Ungual digitules slightly dilated towards the extremity. A group of minute translucent pores on the outer side of the hind coxae. Spiracles approximately of equal size. Cerarii distinguishable on abdominal segments only; seven or eight pairs. Cerarial spines (e) two on each tract; largest on caudal tract, thence becoming gradually smaller and more slender until—towards the base of the abdomen—they become setiform. Cerarial pores in very loose

clusters, scarcely separable from the general body pores, except on the caudal tract, where they are more crowded. Caudal tract slightly but not conspicuously denser than the surrounding area. Dorsal osteoles obscure. Medio-ventral osteoles not apparent. Caudal setae longer, but no stouter than those of the anal ring (c). Body setae moderately numerous; larger on venter; in transverse series across the abdominal segments, crowded on frons. Pores of three distinct types; large tubular pores (f), with broad, mushroom-shaped heads, scattered sparsely over the body; circular discoid pores (g), in irregular series across the abdomen; and numerous obscurely trilobular pores (h), distributed closely over the whole surface.

On roots of *Artemisia argentea*. I. de Cima, Porto Santo.

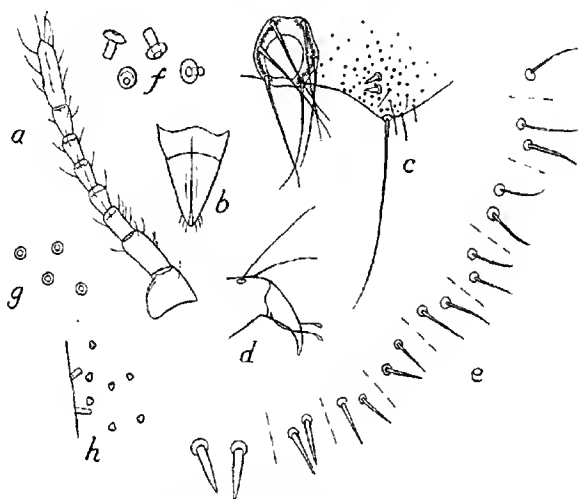


Fig. 4. *Pseudococcus artemisiae*, sp. n.: a, antenna, $\times 130$; b, labium, $\times 130$; c, posterior extremity, $\times 130$; d, foot, $\times 450$; e, cerarial spines, $\times 450$; f, g, h, pores, $\times 450$.

***Lecanium (Saissetia) cerei*, sp. n. (fig. 5).**

Adult female broadly ovate, evenly rounded at both extremities: strongly depressed, almost flat.

Antenna (a) 8-jointed; long and relatively slender; all the joints longer than broad; 3rd longest, 6th and 7th shortest.

Limbs (e) well-developed; tarsus only slightly shorter than tibia; claw short, stout and rather obtuse.

Anal operculum (d) with the outer angles of the valves broadly rounded, the apices obtuse. Anal cleft closely fused.

Stigmatic clefts (b) well-defined, the inner border lunate; each cleft with two strong spines, which extend barely beyond the outer margin.

Marginal setae (c) small, rather widely spaced, relatively stout, the extremity coarsely fimbriate. A slender translucent canal leads inwards from the base of each seta.

The whole dorsum closely set with large, rectilinear, polygonal cells (*f*); each cell containing two concentric, sharply defined areoles; the central areole ovate; the other of very irregular outline; the space between the larger areole and the margin of the cell denser. There is also a minute pore, opening on to the surface, in each cell.

Length 4.75 mm.; breadth 3.75 mm.

Described from a single mature specimen. On *Cereus triangularis*. Funchal.

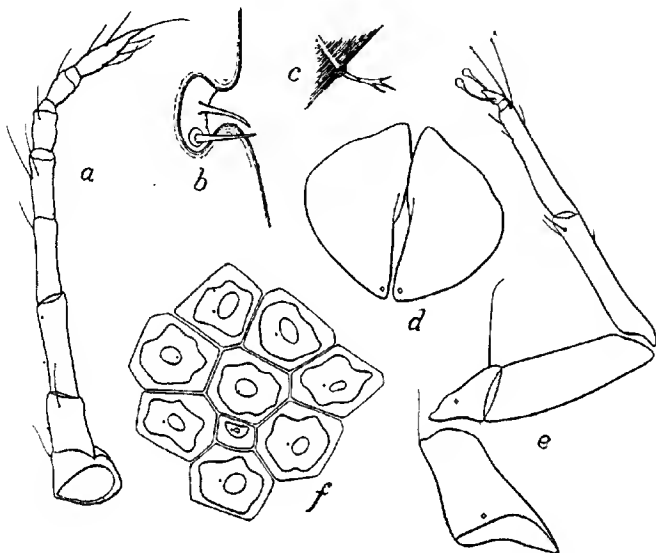


Fig. 5. *Lecanium (Saissetia) cerei*, sp. n.: *a*, antenna, $\times 220$; *b*, anterior stigmatic cleft, $\times 450$; *c*, marginal seta, $\times 450$; *d*, anal operculum, $\times 220$; *e*, mid leg, $\times 220$; *f*, dermal cells from mid dorsum, $\times 220$.

***Ceroplastes denudatus*, Ckll. (fig. 6, c-e).**

Ceroplastes denudatus, Cockerell, "The Entomologist," xxvi, p. 82 (1893).

Ceroplastes tenuitectus, Green, Trans. Linn. Soc. Lond., xii, 2, p. 204 (1907).

Ceroplastes denudatus was described originally from the West Indies (Antigua). The name *tenuitectus* was given by me to a species received from the Seychelles Islands, with which the material from Madeira was found to be identical. I am now satisfied, however, that the two names represent but a single species, *denudatus* having preference. My misidentification of the Seychelles (and subsequently of the Madeiran) insects was based upon material from Demerara (ex coll. J. W. Douglas), which had been wrongly assigned to Cockerell's species. Preparations of the Demerara material show a continuous marginal fringe of spines (see fig. 4, *a*), whereas in my supposed new species from the Seychelles these spines are confined to the neighbourhood of the stigmatic areas (see fig. 4, *b*). Mr. H. Morrison, of the U.S. Bureau of Entomology, has now sent me examples of *denudatus*, from the type material collected in Antigua, which show the same characters as my *tenuitectus*. This necessitates the suppression of the latter name, and the erection of a new specific name for the wrongly determined species from Demerara. I accordingly propose, for this undescribed species, the name *circumdatus*.

Although it is in no way associated with the COCCIDAE of Madeira, it will be convenient to append here the following short description of the differential characters of the new species.

***Ceroplastes circumdatus*, sp. n. (fig. 6, *a*, *b*).**

Superficially resembling *denudatus*, Ckll., but differing from that species in the possession of a continuous marginal fringe of conical spines (*a*); the spines, in *denudatus* being restricted to the four stigmatic areas (*c*), and represented in the intermediate areas by short setae (*d*). The spines of *circumdatus* are more slender and slightly longer than those of *denudatus* (cf. *b* and *e*).

On *Triphasia* sp. Demerara, British Guiana (ex coll. J. W. Douglas).

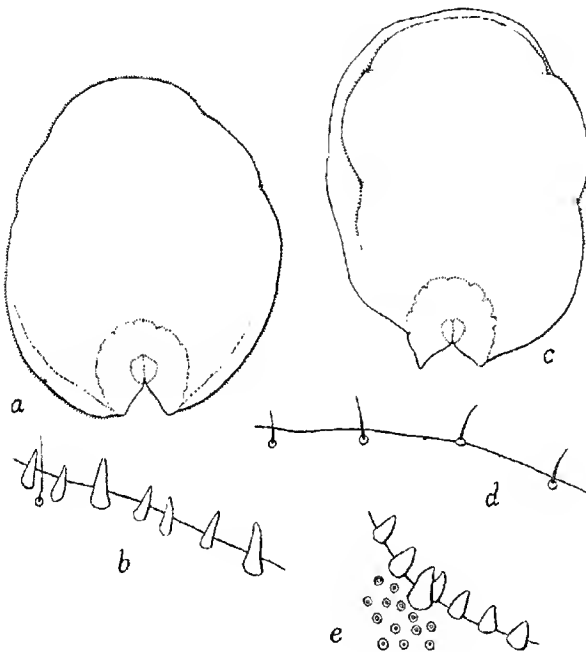


Fig. 6. *Ceroplastes circumdatus*, sp. n.: *a*, young adult ♀, $\times 30$; *b*, part of frontal margin, $\times 450$.

Ceroplastes denudatus, Ckll.: *c*, young adult ♀, $\times 30$; *d*, part of frontal margin, $\times 450$; *e*, spines of stigmatic area, $\times 450$; (in *a* and *c* all but the marginal characters are omitted).

***Targionia laurina*, Ldgr. (fig. 7).**

Targionia laurina, Lindinger, "Die Schildläuse," p. 199 (1912).

As Lindinger's description is unaccompanied by any illustration, I give a figure of the pygidial margin of the adult female insect.

The puparia, which occur on both surfaces of the leaf, are dark brown, with reddish exuviae. They are rather small and inconspicuous. The pygidium is characterised by very prominent median lobes, obscurely indented on each side near the extremity, and by the single pair of strongly bicuspid lateral lobes.

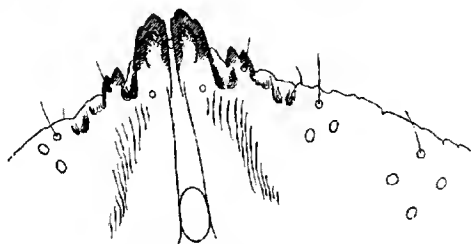


Fig. 7. *Targionia laurina*, Ldgr., posterior margin of pygidium of adult ♀. × 450.

Aspidiotus (Chrysomphalus) pinnulifera, Mask.

Diaspis pinnulifera, Maskell, N.Z. Trans., xxiii, p. 4 (1890).

Chrysomphalus dictyospermi pinnulifera, Fernald, Cat. Cocc. p. 290 (1903).

This insect has, for some time, been regarded as a variety of *dictyospermi*, Morg. After examination of a preparation from Maskell's type material (kindly lent by the U.S. Bureau of Entomology), I am of opinion that Maskell's insect should retain specific rank. It is altogether a more robust species than *dictyospermi*. The pygidium is relatively longer, more prominent and of a more distinctly deltoid form. The apices of the median lobes are parallel or slightly divergent, instead of being convergent—as in *dictyospermi*, and the outermost lobe is more strongly developed. The pinnuliform processes are larger and both their edges are entire, while the same processes of *dictyospermi* have the outer edges coarsely serrate or jagged. The dorsal pores are larger and more numerous. The cristate areas of the lateral margins are longer and more pronounced. These differences may be appreciated by comparison of figure 8, *b* and *d*, though the latter actually represents a variety of *pinnulifera* to be described below. The puparia of both species are of a reddish colour, but those of *pinnulifera* are stouter, rigid in texture, and more opaque.

Typical *pinnulifera* was described from Fiji. It was subsequently recorded from Italy, Jamaica and Demerara; the host-plants being *Croton*, *Cycas*, *Rosa*, *Mangifera*, and *Pandanus*.

Aspidiotus (Chrysomphalus) pinnulifera var. *diversicolor*, n. (fig. 8, *c*, *d*).

Puparium of female differing from that of typical *pinnulifera* in the diverse colouring of the secretory appendix, which varies from blackish or purplish, through various shades of brown, to almost pure white. The exuviae are always reddish.

I can find little or no divergence from the type in the structural characters of the insect itself. The median lobes are, perhaps, slightly fuller and more markedly divergent, and the dorsal pores rather more numerous. The lateral process (*c*) on the thorax is pointed and strongly produced.

A full list of the host-plants has been given in the foregoing catalogue; but the following remarks may be of interest. Examples from *Phoenix dactylifera* (selected as the type material) are dark purplish brown with a paler marginal zone. These dark forms might readily be mistaken for the puparia of *Chrysomphalus ficus*, Ashm. Material from *Dracaena* contains blackish brown puparia intermingled, on the same leaves, with pallid scales, some of which are almost pure white. Examples on *Phoenix canariensis* exhibit a similar variety of tints and some of the scales are particoloured white, with a sharply defined, dark brown zone surrounding the fulvous exuviae.

Musa cavendishi produces a very dark purplish form. The dark forms appear to be by far the more common, occurring on *Citrus*, *Musa*, *Buxus*, *Psidium*, *Phoenix*, *Asparagus*, and *Dracaena*. The whitish form predominates in another gathering from *Buxus*.

Judging from its greater frequency in the gatherings submitted to me, this varietal form must be dominant over the type form in Madeira.

I have examples of var. *diversicolor* from S. Africa also (ex coll. C. K. Brain), where both the dark brown and the white forms occur, intermingled, on leaves of *Citrus* sp.; and, quite recently, I have received an exceptionally dark form from India, upon an orchid (*Cymbidium* sp.).

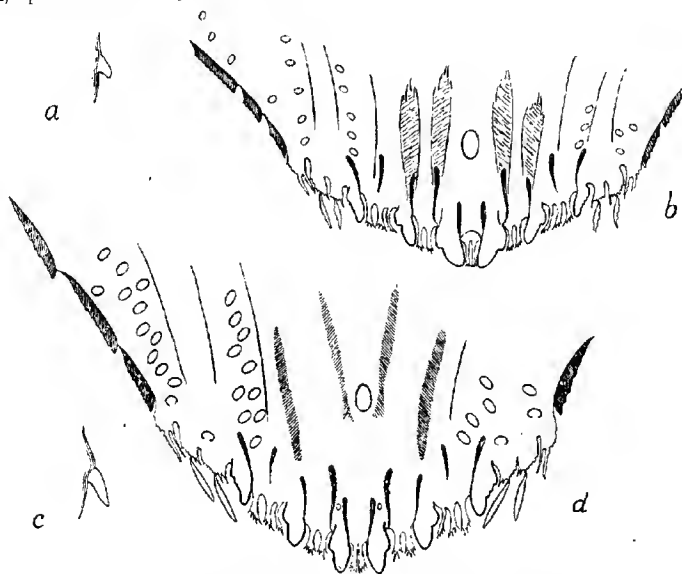


Fig. 8. *Chrysomphalus dictyospermi*, Morg.: a, thoracic spine, $\times 450$; b, margin of pygidium, $\times 450$. *C. pinnulifera* var. *diversicolor*, n.: c, thoracic spine, $\times 450$; d, margin of pygidium, $\times 450$.

It should be noted that Malenotti, in his memoir on "The Supposed Varieties of *Chrysomphalus dictyospermi*" (Redia, xii, pt. 1, pp. 109-123, 1916), refers to this form, which he had received both from S. Africa and Madeira. He notices the strong development and entire margins of the pinnuliform ("cultriform," Malen.) processes, but does not regard these differences of sufficient importance to justify its separation from *dictyospermi*—even as a variety. He states that these special characters of the pinnuliform processes are peculiar to the females possessing blackish puparia, the others having the characters of typical *dictyospermi*. I, on the contrary, have observed blackish, whitish and reddish puparia, all of which were associated with females bearing the special characters of *pinnulifera*.

It may be observed that *Chrysomphalus dictyospermi* also occurs abundantly in the Madeira Islands; but in one instance only (upon *Musa cavendishi*) was it found commingled with *pinnulifera* var. *diversicolor*. In spite of the abundance and close proximity of the two species, I have not seen a single example that could be regarded as an intermediate form.

TWO NEW ANOPLURA.

By JAMES WATERSTON, B.D., D.Sc.

During the course of plague investigations carried out in Kenya Colony in 1921 by the late Dr. R. Van Someren, and in Uganda during 1922 by the same collector in conjunction with Dr. C. A. Baker, some hundreds of Mallophaga and Anoplura were collected, mainly from small rodents. This material was sent to the Imperial Bureau of Entomology in two instalments, and the present paper deals only with a new species and variety represented in the first collection forwarded by Mr. T. J. Anderson, Government Entomologist, Nairobi. The rest of the collection will be dealt with later. The opportunity has been taken to add also the description of a very remarkable louse which infests an Indian tree shrew.

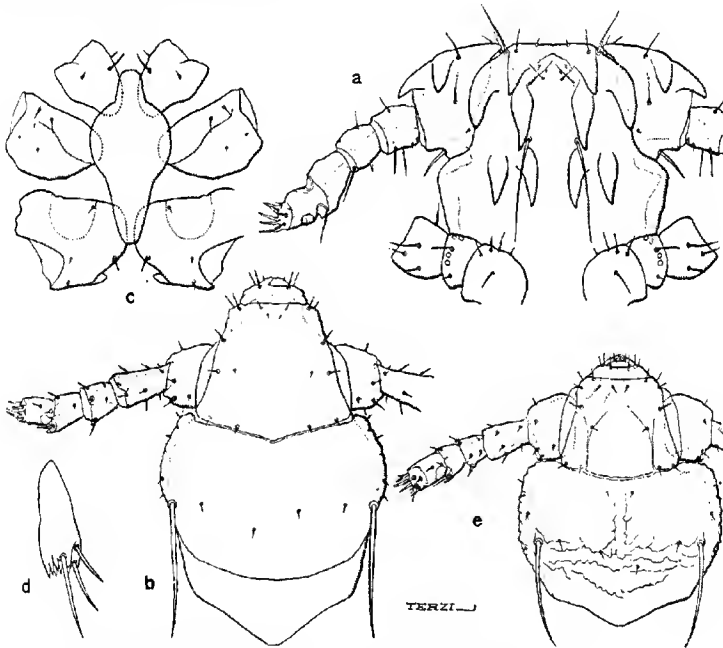


Fig. 1. *Docophthirus acinetus*, sp. n.: a, underside of head of ♂.
Hoplopleura somereni, sp. n., ♀: b, head; c, sternal plate; d, gonopod.
H. intermedia, Kell. & Ferr., var.: e, head of ♀.

***Hoplopleura somereni*, sp. n.**

♀. Length, 1.6 mm.; length of head, 0.25 mm. (laterally) and 0.3 mm. (along mid line); antenna, 0.18 mm.; head and thorax, 0.47 mm. Breadth of head, 0.2 mm.; of thorax, 0.33 mm.; of abdomen, 0.7 mm. (segment 4).

Head (fig. 1, b) somewhat elongate and about half longer than wide if measured to the posterior limit of its insertion into the thorax; well-developed in front of the antennae.

Pleurites (fig. 2, *d*) deeply lobed on dorsal and ventral flaps; the median sinus deep and broad, with the two bristles dissimilar and on very small inconspicuous prominences; pleurite vii produced posteriorly above. Tergites very narrow, i-ii with single row of flattened bristles, iii and viii with two rows, and iv-vii with three rows; on tergites i and iii the arrangement is 1:1 and 3:3 respectively; where there are three rows the numbers are either 6-8 or about 16 in each row. Sternites: the third bears on each side two stout spines on prominences and a finer one, not so based; gonopod (fig. 1, *d*).

♂. Length, 1.4 mm.; length of head, 0.23 mm. (laterally) and 0.25 mm. (along mid line); antenna, 0.19 mm.; head and thorax, 0.47 mm. Breadth of head, 0.2 mm.; of thorax, 0.31 mm.; of abdomen, 0.6 mm. The chief dimensional difference between the sexes is in the length of the abdomen.

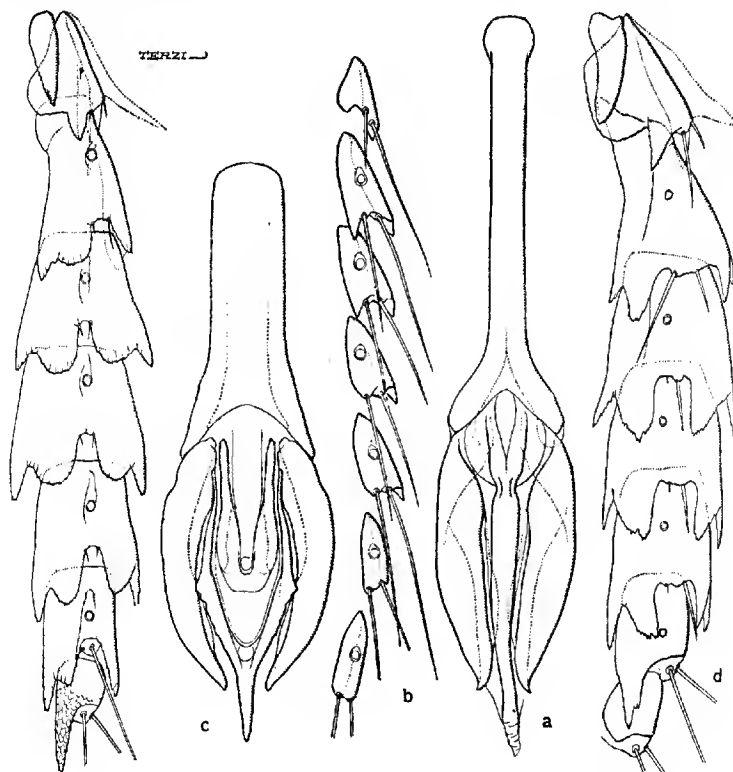


Fig. 2. *Docophthirus acinetus*, sp. n., ♂: *a*, genitalia; *b*, abdominal pleurites.
Hoplopleura somereni, sp. n.: *c*, genitalia of ♂; *d*, abdominal pleurites of ♀.
H. intermedia, Kell. & Ferr., var.: *e*, abdominal pleurites of ♀.

Tergites i-ii as in ♀; tergites iii-vii bear two rows, of which the posterior on iii-v comprises 16-18 bristles arranged 8-9:8-9, while on vi and vii the arrangement is 7:7 and 6:6 respectively; the anterior row on iii and iv is 3-4:3-4, while on v-vii it is 1-2:1-2. These anterior rows are set very little in front of the posterior rows, and on vi and vii the effect is of a bristle slightly out of place on each side.

Sternite ii—4, 4; iii—(a) two heavy and one light spine on each side of mid line, (b) 5, 5; iv—(a) 3, 3, (b) 1, 5, 5, 1, (c) 1, 4, 4, 1; v—(a) 1, 5, 5, 1, (b) 1, 4, 4, 1; vi—two rows 1, 4, 4, 1; vii—1, 2, 2, 1; viii—1, 1. If one takes the single bristles bordering the pleurites they form a distinct longitudinal row on each side. Certain of them have been reckoned in the above enumeration, e.g., the single bristles in the row 1, 4, 4, 1; but there are others (single) not enumerated above, e.g., on iv and vi, interpolated between the transverse rows at the sides, which may indicate rows otherwise obsolete.

Genitalia (fig. 2, c) with stout parameres.

Type ♀ in the British Museum.

Host: *Dasymys helukus*, H.

KENYA COLONY: Wamia, Okedi Camp, 23.vii.1921 (R. Van Someren).

Hoplopleura somereni, sp. n., is a member of the *neumannii* group. It is sufficiently distinguished by the pleurites, whose lobes are very broad, and by the elongate sternal plate. I am indebted to Prof. Ferris for a note that it is closest to *H. veprecula*, Ferr., a species not represented in the British Museum collection.

***Hoplopleura intermedia*, Kell. & Ferr., var.**

Hoplopleura intermedia, Kellogg & Ferris, Ann. Durban Museum, i, pt. 11, pp. 153–154, pl. xvi, figs. 5, 5 a–d (15.v.1915); Ferris, *ibid.*, pt. 111, pp. 243–245, 247, text fig. 27 (20.iv.1916); Ferris, Proc. Cal. Acad. Sci. (4) vi, p. 156, no. 9, p. 194 (12.v.1916); Ferris, Stanford Univ. Pub. Biol. Ser. ii, no. 2, pp. 60 & 90–92, figs. 54, 55 b & c, 56 b (1921).

Originally described (from Mfongosi, Zululand) from *Mus coucha*, which appears to be the main host, though also recorded (1921) from several other African Murids. In the Anderson collection are many examples from *Rattus coucha ugandae*, de Wint. Like their host, these Uganda examples represent a sufficiently distinct race. The head (fig. 1, e) appears to be typical, but the pleurites (fig. 2, e) are more deeply lobed (cf. Ferris (1921), figs. 55 & 56).

Genus ***Docophthirus***, nov.

Anoplura without eyes; with five-jointed antennae, which are similar in the two sexes, first antennal joint strongly developed, bearing like the underside of the head, several short, heavy, sharp, backwardly directed, anchoring processes. Thorax without a defined sternal plate. Fore pair of legs small, mid and hind pairs equal and strong, with a long stout and rather sharply pointed claw, opposed by a process of the strongly produced tibia. Abdomen deeply serrate at sides, especially in the ♀, the teeth being formed of segmental lobes capped by the small pleural plates; the latter occur on segments ii–viii, but are without free edge, feebly chitinated and indefinitely bounded on some of the posterior segments (vii and viii in genotype). Abdominal chaetotaxy: tergites and sternites with one row of bristles in the ♂ and two, for the most part, in the ♀.

Genotype: the following species:—

***Docophthirus acinetus*, sp. nov.**

A somewhat elongate species, easily recognised by its strongly armed, flatly truncate head and the quadrate facies of the head in conjunction with the very large first joint of the antennae (♂, ♀), and also by the elongate serrate abdomen.

♂. Head (fig. 1, a) with length and breadth subequal; anterior edge perfectly straight, and, measured at the antero-ventral hairs, only about half the breadth at the eyes; for roughly half its length and one-fourth the breadth at each side the head is anteriorly excised to receive the relatively enormous first antennal joint, which bears three stout teeth; ten more occur on lower surface in the positions indicated. The whole head is strongly chitinated, especially laterally, from the eyes backwards; dorsally on each side, one stout postero-lateral spine, with a row of about five minute

bristles running forward parallel with the edge. For chaetotaxy of lower surface see fig. 1, *a*. Thorax not separated from the head by a definite constriction but laterally continuous with head, roughly trapezoidal, a little broader than long (6:5), dorsally with one stout antero-lateral metathoracic spine with a few minute bristles postero-laterally; on sternal surface one fine bristle on inner side at the insertion of the coxae. Legs with the claws long, pointed straight; the spine of the opposing process stout in mid and hind legs. Abdomen two and a half times as long as head and thorax combined, and about one-third broader. Pleurites (fig. 2, *b*) apparently wanting on segment i, distinct but rather small on ii-v, reduced much more on vi, and demonstrable on vii and viii only by prolonged staining; spiracular area of pleurites rather large; each pleurite with two bristles. Tergites and sternites not strongly chitinated, though well-defined after staining; chaetotaxy as follows: sternites i-iii, 7-4 bristles (2:2); iv-vi, 9 (one at each side near pleurite and seven medianly (3:1:3)); vii, 7; viii, 4; ix, 2. Tergites i-iii have 2, 4 and 6 bristles respectively. Otherwise like the sternites.

Genitalia: the apparatus (fig. 2, *a*) extends backwards through one-third of the abdomen; of its length the slender basal plate occupies half; parameres broad and heavy; functional penis apically expanded. Length, 1.3-1.4 mm.; genitalia, 0.3 mm. Breadth: head, 0.21 mm.; antennae, 0.24 mm.; thorax, 0.28 mm.; abdomen, 0.38 mm.

♀. Similar to ♂ but considerably larger, the difference being chiefly in the abdomen, which is over thrice as long as the head and thorax combined. Pleurites developed to about the same extent as in the ♂, but the abdominal tergites and sternites hardly visible when unstained, and after prolonged staining very short and indefinite. Chaetotaxy: tergite i, 2 (1:1); ii, 6; iii, 8; thereafter up to the eighth segment there are two rows of dorsal bristles as follows: iv, 8, 10; v-vi, 9, 12; vii, 9, 14; viii, 6, 9; and 5 or 6 bristles behind on ix. Sternites i-ii, 2; iii, 6, 6; iv, 8, 8; v-vi, 9, 9; vii, 0, 6. Length: 1.9-2 mm.; antennae, 0.25 mm. Breadth: head, 0.22 mm.; thorax, 0.3 mm.; abdomen, 0.54 mm.

Type ♂ in the British Museum.

Host: *Anathana ellioti*, Waterhouse.

INDIA: Madras (Beddome Coll.), 2 ♂♂, 2 ♀♀; also 1 ♂ with data uncertain.

This is unlike any other described Anopluran known to me except *Haematopinus* (*Polyplax*) *aculeatus*, Neumann, Bull. Soc. Zool. Fr., xxxvii, pp. 143-145, figs. 5-6, 1912, which is probably congeneric with the present insect rather than with *Eulinognathus denticulatus*, Cumms., with which, however, Neumann's species has been placed. The chief points of resemblance are in the shape and armature of the head and in the abdominal pleurites: Neumann's species described from *Dipus* sp. (PEDETIDAE), from Djerba, Tunis, is compared by its author with *Hoplopleura maniculata*, Neum., and *H. spiniger*, Burm., with neither of which, however, does it appear to have any close affinities.

NOTES ON PARASITIC HYMENOPTERA.

By JAMES WATERSTON, B.D., D.Sc.

Hymenopterous Parasites of Brassolid Butterflies.

During the past fifteen years the attention of Economic Entomologists in Central America and the West Indies has been increasingly directed to the damage done by species of the genus *Brassolis* to the foliage of coconut and other palms. In some of the scattered papers (*q.v.* Review of Applied Entomology, Series A, 1913-22) dealing with these ravages one finds references to the natural control exercised by Hymenopterous parasites. So far as I am aware the only writers to mention by name any of these enemies are C. Schrottky (1909) and G. E. Bodkin (1917), who list four species between them. Since the spring of 1920 I have examined two small collections of Hymenopterous parasites of *Brassolis* from Trinidad and British Guiana respectively. In each of these the same one of Schrottky's species is represented, and in all I am now able to list seven species. Two of these have not been seen by me, and two more (*Brachymeria* and *Spilochalcis*) are probably recognisable from extant descriptions. In the case of the *Telenomus* it is hoped that the figures given may facilitate recognition. Though Ashmead's description of this species is very incomplete, I have forborne for the present to supplement it, since the diagnosis of these minute parasites for any particular geographical area can be attempted best in a comparative key. Only the *Anastatus* has been fully described. Mr. F. W. Urich intends later to publish an account of the bionomics of the species he has reared in Trinidad. It should be noted that the egg and larva of the host have each yielded two and the pupa three of the parasites now enumerated.

Superfamily ICHNEUMONOIDEA.

Family BRACONIDAE.

***Apanteles opsiphanis*, Schrott.**

Apanteles opsiphanis, Schrottky (C.), An. Soc. Cient. Argent., lxxvii, p. 211 (May, 1909).

"Folliculi albi plus minusve 130 in latere ventrali larvæ *Opsiphanis crameri*, Feld., dispositi sunt."

PARAGUAY: Puerto Bertoni.

Superfamily CHALCIDOIDEA.

Family CHALCIDIDAE.

As Mr. A. B. Gahan has recently reminded us (U.S. Nat. Mus. Bull., 124, p. 31, 1923), *Chalcis*, F., is an older name for *Smiera*, Spin., and should be so used. In the rearrangement thus made necessary *Chalcis*, auct., is replaced by *Brachymeria*, Steph.

***Brachymeria annulata*, F.**

Chalcis annulata, Fabricius, Syst. Ent., ii, p. 195 (1793).

Chalcis annulata, F., Bodkin, Trans. Ent. Soc., p. 320 (1917).

BRITISH GUIANA.

"A common parasite of *Brassolis sophorae*, L., and also *Caligo ilioneus ilioneus*, Cramer," according to Bodkin (*loc. cit.*), who adds that this species is widely distributed and the commonest Chalcid in the Colony.

Brachymeria incerta, Cress.

Chalcis incerta, Cresson, Proc. Ent. Soc. Philadelphia, iv, p. 101 (1865).

BRITISH GUIANA: Demerara East Coast, Mahaicony, Plantation Park, 5.ix.1922 (L. D. Cleare, Jr.).

♂ and ♀ (both defective), with fragments of three more ♀ ♀, from pupa of *Brassolis sophorae*, L., from Plantation Park, Mahaicony. I determined this material from Mr. J. C. Crawford's table in his "Description of certain Chalcidoid Parasites" (Technical Results from the Gipsy Moth Parasite Laboratory; U.S. Dept. Agric. Bur. Ent., Techn. Ser. no. 19, pt. 11, 1910), and Mr. A. B. Gahan tells me that the Demerara specimens are apparently the same as others standing under this name in the United States National Museum from Miami, Florida. The type locality of *B. incerta*, Cress., is Cuba, and Mr. Gahan thinks the type is probably in Havana.

Spilochalcis morleyi, Ashm.

Spilochalcis morleyi, Ashmead (W. H.), Mem. Carnegie Museum, i, no. 4, pt. 2, pp. 426 & 441 (i, 1904).

Spilochalcis brassolis, Schrottky (C.), An. Soc. Cient. Argent., lxxvii, p. 210 (1909).

TRINIDAD: Chaguanas, i.1920, many ♂ ♂ and ♀ ♀ from pupa of *Brassolis* sp. (F. W. Urich). BRITISH GUIANA: Mahaicony, Plantation Park, 5.ix.1922, a series (♂ ♂) from one pupa of *Brassolis sophorae* (L. D. Cleare, Jr.).

Originally described from Bahia, Brazil, 19.iii.1883 (A. Koebele), without mention of a host.

Schrottky bred numerous examples of his *S. brassolis* from a chrysalis of *B. sophorae*, L., from Puerto Bertoni, Paraguay. Mr. A. B. Gahan, who has kindly compared some specimens with Ashmead's type for me, agrees in this determination and adds: "We have here (U.S. Nat. Mus.) a good series reared from *Opsiphanes invirae*, Hübn., at Bahia, Brazil." *O. invirae* is a Brassolid nearly related to *B. sophorae*.

Family EUPELMIDAE.

Though the following Eupelmid has ultimately proved to be a known species, it has seemed well to give a detailed account of the insect, partly to supplement the original description and partly because the Brassolid parasites are on the average about one-fourth or one-fifth shorter than the specimens on which Dr. Howard founded his *Eupelmus reduvii*, and have a proportionately lesser expanse.

I wish to thank most heartily Mr. A. B. Gahan, of the Bureau of Entomology, U.S. Dept. Agric., Washington, for the trouble he has taken in deciding the determination of the insect. Our joint opinion at first was that the Trinidad material represented a new species, since it agreed with none of the described species of *Anastatus* represented in the British Museum and the U.S. National Museum. A perusal of the literature suggested the advisability of a comparison of Mr. Urich's insect with *Anastatus pleuralis*, Ashm. (1904), of which the type is at Pittsburg. This examination Mr. Gahan was enabled to make, thanks to the courtesy of the Director of the Pittsburg Museum. Apart from a considerable difference in size, he could find no tangible morphological distinction between the specimens compared. At the same time he came definitely to the conclusion that both were referable to an *Anastatus* already described as *Eupelmus reduvii*, How.

Mr. Gahan has also sent me eight lots of *Anastatus* (considered to be probably all *A. reduvii*) from various Lepidopterous and Hemipterous eggs. These show a considerable range in size, but up to the time of going to press I have been able to examine critically only a ♀, which is marked definitely "*reduvii*, How., compared with type," (from eggs of *Arilus cristatus*, Bladensburg, Maryland, U.S.A.). The agreement between this and the Trinidad specimens is very complete.

Anastatus reduvii, How.

Eupelmus reduvii, Howard (L.O.), Can. Ent., xii, p. 207-208 (1885).

A moderate-sized species, blackish brown,* with paler legs whose femora and tibiae are broadly darker streaked, belonging to the *bifasciatus*, Fonsc., group, and distinguished by the rather broad, pale median band of the forewing (♀) and the proportions of the antennal joints.

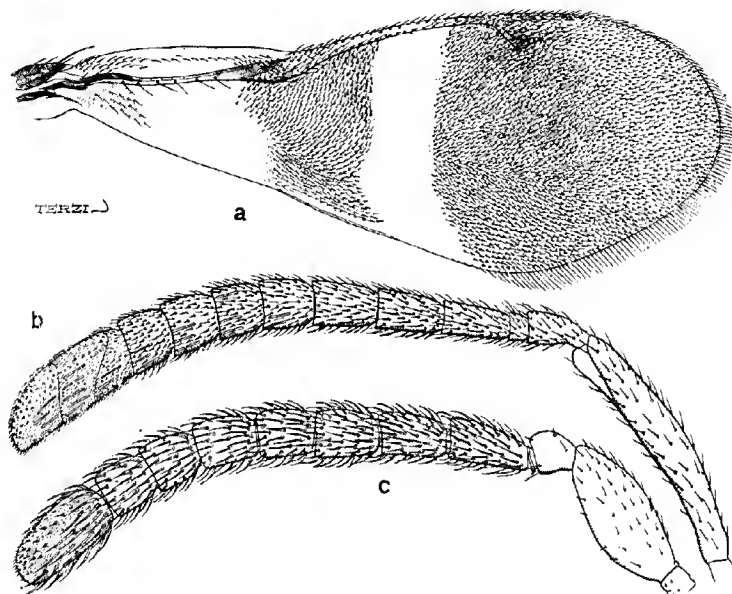


Fig. 1. *Anastatus reduvii*, How.: a, forewing of ♀; b, antenna of ♀; c, antenna of ♂.

♀. Head black, metallic reflections not very strong—mainly dark green, more violaceous on the lower face medianly above the toruli, with a coppery superimposed tinge, especially across the vertex. Trophi brown, first three joints of maxillary and all of the labial palpi pale; mandibles apically dark brown. Scape yellowish, pedicel paler beneath, otherwise with the funicle blackish brown to black. Thorax, entire meso- and metanotal surface, together with mesopleurae (anterior half) and sterna, very dark. Scutellum from above matt, but metallic and refringent from other angles. The other dark regions of the thorax show more or less decided metallic reflections; thorax otherwise clear brown, non-metallic or practically so; protergites infuscated near spiracles. Abdomen blackish brown, with broad whitish sub-basal band extending over the posterior half of tergite i (3) and all of ii (4) and the first two sternites; at most submetallic dorsally. Ovipositor-sheath pale. Legs mainly brown; mid and hind coxae darker and submetallic; all femora and tibiae with more or less (anterior legs) distinct broad, dark dorsal stripe; tarsi pale, with fifth joint and claws darkened; in the mid tarsus the first three joints (with the tibial spur) are nearly white and the heavy spines black. Wings (see fig. 1 for pattern) strongly infumated, with two pale bands; a little lighter towards apex.

* After being in spirit, in which the metallic reflections suffer, some of the specimens are bleached.

Head broader than deep (6:5); eyes bare, at the level of the anterior ocellus separated by rather over one-third and at the base line by three-fourths of the breadth; toruli about four-fifths below the base of the eyes; pattern on vertex, upper face and orbits fine, strongly raised reticulate, the walls of the reticulation relatively thick; impressed area above toruli finely coriaceous; mouth-edge straight and smooth, entire surface with short but strong pile, the bristles near the orbits longer. Antenna (fig. 1, *b*): scape (16:3) longer than pedicel (2:1), ring joint and first two normal joints of the funicle taken together; funicle and club 34:32:34:28:28:25:25 and 30:25:32, with breadths 15:18:21:24:25:25:26 and 30:25. Labrum simple transverse narrow, with six bristles. Maxillary palpi, 7:9:9:24; labial palpi, 12:6:12. Mandibles bidentate, the lower tooth short and acute, the upper broad and straight-edged.

Thorax (fig. 2, *a*) distinctly narrower than the head (about 7:8), and with propodeum much longer than abdomen (4:3). Pattern and chaetotaxy of notal surfaces as in the figure; basal scutellar abscissa occupying about one-fourth of the suture. Mesosternopleurae; sternal and pleural areas separated by a clear (weakly chitinised), moderately broad line; the oblong sternal area thus enclosed is 5 by 2, with large raised pattern for about one-fourth anteriorly and becoming smooth posteriorly; on the smooth posterior three-fourths there are in all about 40 minute scattered bristles and twelve in a transverse posterior row, considerably longer. Pleural surface rougher (raised reticulate) anteriorly with short, stiff, glistening bristles over an area extending one-third dorsally and to one-half ventrally (*i.e.*, along the clear sterno-pleural line). Posteriorly closely and finely striate but not so smooth as the adjacent sternal area.

Wings: forewings (fig. 1, *a*) about 8:3; hind wings 17:5.

Legs: fore leg with femur (10:3) about one-sixth longer than the tibia (5:1); at apex of latter two short, heavy, peg-like spines dorsally and externally, and a comb of about nine spines; tarsus long, two-thirds the femur and tibia combined; comb of first joint about 20 spines, joints in ratio 70:42:32:27:42. Mid leg with femur (5:1) shorter (5:6) than tibia (7:1), with 3-4 peg-like spines at apical ventral angle; tibial spur as long as the first tarsal joint dorsally; plantar spines 25-30:9:4:2:0; proportions of tarsal joints 65:45:30:30:42. Hind leg with femur (5:1) longer (8:7) than the curved tibia (10:1), which, again, is distinctly longer (15:13) than the tarsus; tibial comb with 12 spines; longer spur two-fifths the first joint; tarsus in ratio, 100:55:40:32:45.

Abdomen with 1st (3rd) and 2nd (4th) tergites broadly concave posteriorly, the first, in addition, being shortly split posteromedianly and chitinised only on its anterior half; 2nd tergite membranous; tergites iii-vi practically straight-edged posteriorly; vii strongly convex; surface of iii-vii with increasingly raised transverse reticulation (nearly striate), but behind the stylet more regular; tergites approximately in ratio 23:23:16:14:12:16:5; sternites (mid line) approximately 13:12:10:11:8; only the last at all coloured or appreciably chitinised.

Length, 1.5-2.3 mm.; alar expanse, 2.6-4 mm.

♂. Black, with very dark metallic reflections. Scape yellowish brown, with a darker streak towards the apex dorsally; antennae otherwise nearly black. Trophi as in ♀, but all the joints of the palpi (except the faintly darker tip of the fourth maxillary) pale. Wings hyaline. Legs with coxae blackish brown (with apical third pale in fore legs); trochanters, knees and basal half of mid and hind tibiae and joints 1-2 of their respective tarsi, white; all femora, apical half of tibiae in mid and hind legs, with joints 4-5 of their tarsi, blackish brown or black. In the fore legs the tibia is whitish, indefinitely infuscated at the apex ventrally (to about one-half); all the tarsus faintly infuscated, but not so dark as the two last segments of the mid and hind tarsi.

Head (6:5): eyes with a few scattered bristles, at level of anterior ocellus separated by two-fifths and on the base line by nearly five-sixths the breadth; malar space

about two-thirds the eye depth. Antenna (fig. 1, c) : scape (15 : 7) a little longer than the pedicel (9 : 8), ring joint and the first funicular together ; funicle, 14 : 11 : 11 : 10 : 10 : 8, and club 20, increasing gradually in width from $6\frac{1}{2}$ to 8 (club) ; there are no long sensoria. Mouth-parts as in ♀.

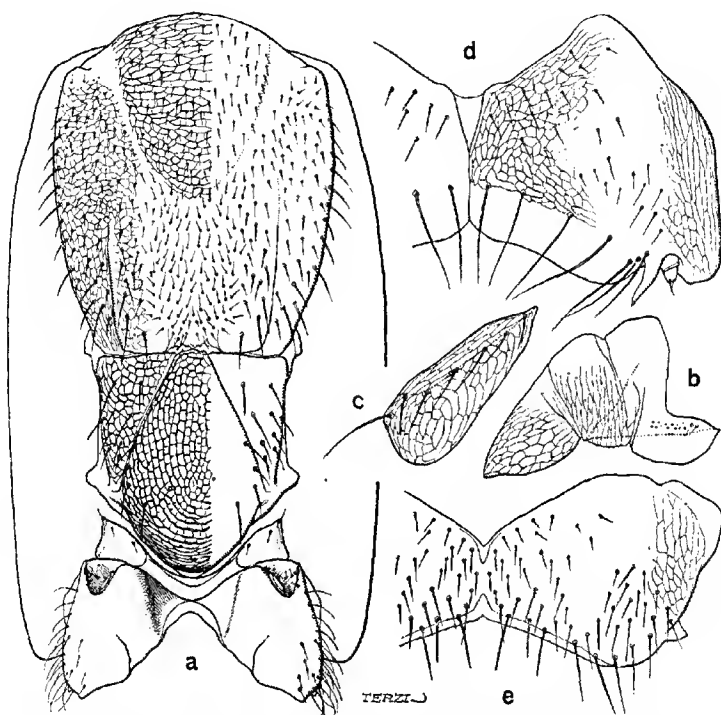


Fig. 2. *Anastatus reduvii*, How. : a, mesothorax, metathorax and propodeon of ♀ ; b, prepectus of ♀ ; c, tegula of ♀ ; d, protergum of ♀ ; e, protergum of ♂.

Thorax much narrower than the head (5 : 6). Pronotum (fig. 2, e) with a distinct spiracular process, the two half tergites more closely united than in ♀. Mesonotal pattern strongly raised, especially on scutellum. Axillae nearly touching, separated by about only a tenth of the distance between the deeply impressed parapsidal furrows. Mesosternopleural surface nowhere smooth but less raised ventrally, coarser at sides, and on prepectora ; middle area (post-scutellum) of metanotum strongly raised reticulate. Propodeon, normal, rather broad, with short median keel, nearly smooth ; spiracle and sulcus much as in ♀.

Wings : forewings (2 : 1) definitely broader than in ♀ ; submarginal, marginal, radius, post-marginal, as 10 : 6 : 3 : 4 ; about 15 bristles on radius. Hind wings (10 : 3) practically as in ♀, with about 30 minute bristles on the submarginal cell, mainly at the edge.

Legs : fore legs with femur (3 : 1) one-seventh longer than the tibia (4 : 1) ; apical tibial comb with 5-6 spines ; peg-like spines and tarsal comb as in ♀ ; tarsal joints, 60 : 27 : 23 : 21 : 33. Mid leg with femur (4 : 1) and the proximal part of the trochanter

together exactly equal to the tibia (7 : 1); spur and first tarsal joint subequal; 8-9 sharp spines ventrally on first joint; tarsal joints, 50 : 32 : 23 : 21 : 30. Hind legs with coxae (2 : 1) large and coarsely sculptured, two-thirds the femur (10 : 3), which is subequal to the tibia (11 : 2), the latter distinctly longer (7 : 6) than tarsus, the joints of which are as 50 : 30 : 25 : 21 : 33.

Abdomen distinctly shorter than rest of body and just longer than thorax; petiole very short and rugulose. Tergites in ratio i (iii), 4; ii-vi, 3; vii, 2; and sternites i-vii in ratio (apparently) 60 : 40 : 30 : 50 : 45 : 45 : 45, measured along the mid line, where there is considerable overlapping. In reality sternites ii-vii (seen at sides) are subequal, while i is about one-fourth longer. The surface of the tergites is smoother medianly and more raised reticulate laterally, and tergite i is narrowly rugulose (to nearly one-half) behind the petiole; tergites ii-vi bear on each side of the mid line three small, clear, oval sensory areas.

Length, 1.2-1.8 mm.; alar expanse, 2.2-3.4 mm.

Type ♀ in the British Museum, one of a series of both sexes reared from eggs of *Brassolis* sp.

TRINIDAD : Chaguanas, i. 1920 (F. W. Ulrich).

Mr. A. B. Gahan (*in litt.* 9.iv.1923) writes : "I also find that in 1921 I received a single imperfect female specimen, reared by Mr. J. Zetek, April 8, 1921, at Ancon, Canal Zone, Panama, from *Brassolis isthmia*, which I determined at the time as *Anastatus* sp."

Family EULOPHIDAE.

Genus *Pseudomphale*, Schrott.

Mr. A. B. Gahan (*in litt.*) has drawn my attention to the fact that in Girault's opinion (Can. Ent., xlvii, p. 234, 1915) *Pseudomphale*, Schrott. (1909) is a synonym of *Horismenus*, Wlk. After comparing the description of Schrott's genus with the unique type of *Entedon cleodora*, Wlk. (1843) (the type of *Horismenus*, Walker, 1843), I am inclined to agree with Girault, and have here adopted the synonymy proposed. Though Walker subsequently (1846) sank his *Horismenus* as a synonym of *Entedon*, Dalm., Ashmead rightly (1904) treated the two as distinct genera.

Horismenus opsiphanis, Schrott.

Pseudomphale opsiphanis, Schrottky (C.), An. Soc. Cient. Argent., lxxvii, pp. 209-210 (v.1919).

A female reared from a larva of *Opsiphanes crameri*, Feld. Appended to the generic diagnosis is the following note : "Biologia hujus generis valde singularis generibus Braconidarum *Apanteles* etc. similis. Larvae folliculum extra corpus hospitis [*sic*] faciunt." It is more probable, however, that the *Pseudomphale* is a hyperparasite of *Opsiphanes* through *Apanteles opsiphanis*, whose cocoons may have been mistaken for those of the Chalcid by the author. No locality is mentioned, but presumably it was Puerto Bertoni, Paraguay.

At least one other species of the genus, viz., *H. nigroaeneus*, Ashm., is known as a hyperparasite through an *Apanteles* (see Waterston, J., Proc. Ent. Soc. London, 1921, p. 2).

Superfamily SERPHOIDEA.

Family SCELIONIDAE.

Telenomus nigrocoxalis, Ashm.

Telenomus nigrocoxalis, Ashmead (W. H.), Journ. Linn. Soc. (Zool.), xxv, pp. 211-212 (1894).

TRINIDAD : Chaguanas, i. 1920 (F. W. Ulrich).

A series (♂, ♀) from eggs of *Brassolis* sp. These specimens agree well with the unique type in the British Museum, a ♀ taken in St. Vincent. The drawings are from the Trinidad material.

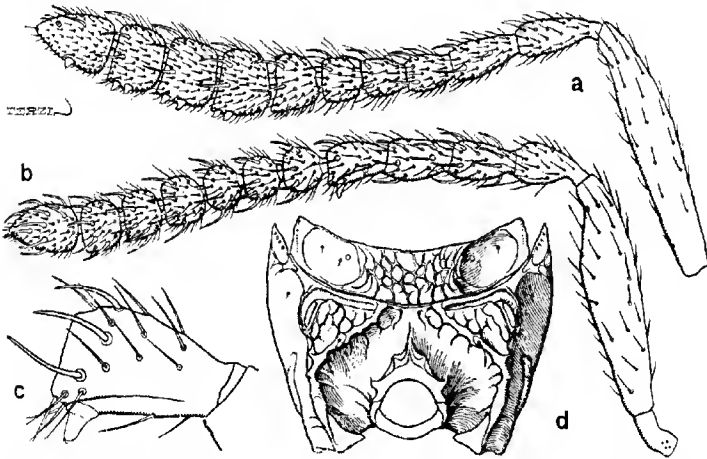
*List of Hosts and Parasites.****Brassolis sophorae*, L.***Brachymeria annulata*, F.
Brachymeria incerta, Cress.*Spilochalcis morleyi*, Ashm.***Brassolis isthmia*, Bates.***Anastatus reduvii*, How.***Brassolis* sp.***Spilochalcis morleyi*, Ashm.
Anastatus reduvii, How.*Telenomus nigrocoxalis*, Ashm.***Caligo ilioneus ilioneus*, Cram.***Brachymeria annulata*, F.***Opsiphanes crameri*, Feld.***Apanteles opsiphanis*, Schrott.*Horismenus opsiphanis*, Schrott.***Opsiphanes invirae*, Hb.***Spilochalcis morleyi*, Ashm.

Fig. 3. *Telenomus nigrocoxalis*, Ashm.: a, antenna of ♀; b, antenna of ♂; c, sensorium of third funicular joint of ♂; d, propodeon of ♂.

A New Psyllid Parasite.**Superfamily CHALCIDOIDEA.****Family PTEROMALIDAE.**

The following description should be compared in detail with that of *Pachyneuron crassiculme*, Waterst. (Bull. Ent. Res., xiii, pt. 1, p. 51, fig. 5, 1922), to which the Californian species is very closely related. It should be noted that fig. 4, d, is a composite of two side-views, and is therefore not strictly comparable with fig 5, d (loc. cit.), which was taken from directly above the mid line of the propodeon.

***Pachyneuron validum*, sp. n.**

♀. Similar in coloration to *P. crassiculme*, Waterst., but darker and duller with only the faintest metallic gleams on the propodeon, posterior coxae and dorsum of abdomen basally. On each side of the middle of the propodeon is a dull matt longitudinal streak running forward to and connecting with the more admedian of the anterior hollows behind the metathorax. Antennae entirely blackish brown, palpi (maxillary) infuscated, paler only on the fourth joint. All coxae, trochanters and femora (except the extreme tip of the latter) nearly black; in mid legs the junction of trochanter and femur obscurely paler; extreme base of all the tibiae pale; fore tibiae strongly infuscated (blackish) both dorsally (more narrowly) and ventrally (broadly) and paler between; mid tibiae (for one-tenth) and hind tibiae (about one-fifth) pale distally, otherwise nearly black; fore tarsus and fifth joint of mid and hind tarsus infuscated; hind and mid tarsus otherwise pale. Wing nervures blackish brown, distinct.

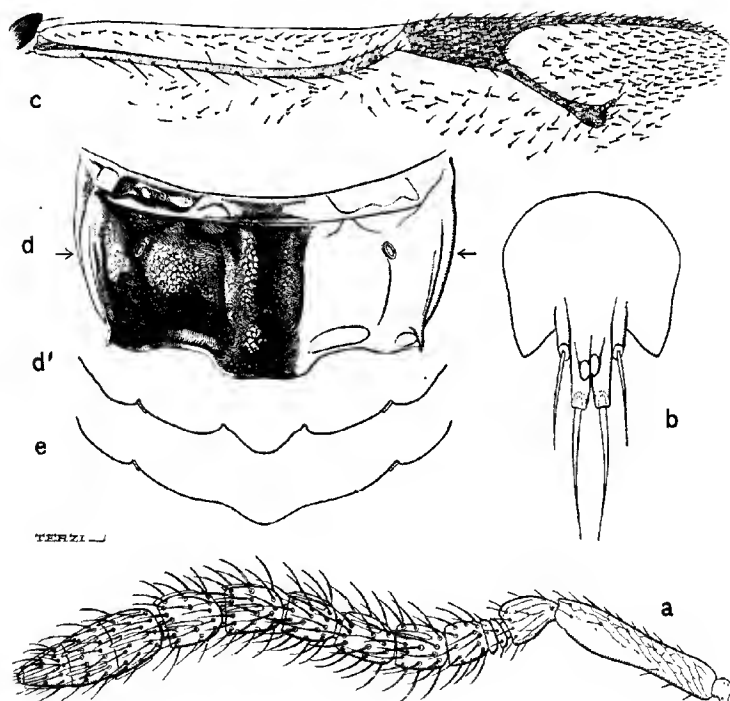


Fig. 4. *Pachyneuron validum*, sp. n.: a, antenna of ♂; b, labium of ♀; c, neurulation of forewing of ♀; d, propodeon of ♀ (see text); d', optical section of d from in front across line of arrows; e, a similar section in *P. crassiculme*, Waterst., ♀.

Head and thorax as in *crassiculme*, except that the pattern is everywhere more raised, with the result that the parapsidal furrows can be traced back practically to the suture. Propodeon (fig. 4, d) relatively shorter than in *crassiculme* and smoother medianly, but with pattern much more strongly raised along the matt lines, between which and the spiracular folds the surface is smoother and more swollen than in *crassiculme*. Spiracle more outwardly directed and from above seen mostly in profile.

Antenna, length 0.67 mm.; scape and pedicel exactly as in *crassiculme*; the second funicular (beyond the two ring joints) shorter than (about three-fourths) the third, the fifth distinctly (about one-sixth) longer, while the sixth is just shorter than the fourth; club equal to the last three funicular joints taken together, with three equal segments; sensoria of funicle 0, 0-1, 2-3, 3-5, 6, 6-7, and of club 10, 11-12, 8-9. Labrum (fig. 4, b); maxillary palpi, 10 : 15 : 13 : 26, *i.e.*, the second joint distinctly longer than the third; labial palpi, 14 : 5 : 17.

Wings: forewings (fig. 4, c), length 1.1 mm., twice as long as broad; submarginal: marginal; radius: post-marginal, as 15 : 4 : 5 : 8; more exactly the radius is about one-fifth longer than the marginal, the latter being very greatly thickened and varying from about five (at its junction with the submarginal) to two and a half (at the base of the radius) times as long as broad; radial knob less than one-half and the radius basally about one-fifth the greatest width of the marginal. Chaetotaxy: 12 longer bristles on submarginal (up to the clear pustules) and about half a dozen (fig. 4, c) shorter ones between the pustules and the costa; on edge of marginal 8-9 stiff bristles and over 30 more on its surface arranged in 3-5 irregular rows, radius with 15-16 bristles, post-marginal with about 15 bristles at edge and 40 on surface in two rows. Hind wings (4 : 1), length 0.87 mm.

Legs: comb of first tarsal joint of fore legs with 15 spines, tibial comb of hind legs with 14 spines. In all the tarsi the first joint is relatively longer than in *crassiculme*; the proportions are:—

	Joint	i	ii	iii	iv	v
Fore	..	32	23	18	13	24
Mid	..	43	26	21	16	24
Hind	..	43	29	23	16	25

Length, 1.5 mm.; alar expanse, 2.7 mm.

♂. Differs as regards colour from the ♀ mainly in the paler legs, the pale apical area of the femora being more extensive; in the fore leg the tibia is pale at base and apex, ferruginous and more or less infuscated elsewhere; in the mid tibia there is a blackish band, extending for about one-fourth, beyond the narrowly pale base, the joint becoming gradually paler distally; hind tibia apically broadly pale, darker on basal band to about one half; tarsi as in *crassiculme* and in ♀, but those of the fore legs are ferruginous rather than infuscated; all junctions of trochanters and femora paler.

Antenna (fig. 4, a), length 0.78 mm.; scape (about 9 : 2) widest at one-third before the apex, three times the pedicel (5 : 3) and equal to the two ring joints, the first three and about one-fourth of the fourth funicular joints; club shorter than the three preceding joints taken together; proportions of the funicular joints, 15 : 20 : 23 : 22 : 24 : 23, and of club, 22 : 20 : 23; in the same ratio the breadths (without pressure) are 14 : 15 : 15 : 16 : 17 : 18, and 22 : 17 sutures; sensoria 0, 2, 2-3, 2-3, 3-4, 3-4, and club 5, 6-7, 3-4. The first funicular and the last two joints of the club have two transverse rows of bristles, the others three.

Sculpture of head and thorax as in ♀. Propodeon a little more produced posteriorly and more rounded between the matt admedian line and the spiracular fold than in ♀; petiole about as long as the hind coxae. Forewing, length 1 mm.; hind wing, length 0.85 mm. Proportions and chaetotaxy as in ♀. Legs with the tarsal proportions of joints iii-v as in ♀, and i and ii a little shorter. *Length*, 1.3 mm.; alar expanse, 2.4 mm.

Type ♀ in the British Museum, one of a pair (♂, ♀) bred from a Psyllid, *Euphyllura arbuti*, Schwarz.

CALIFORNIA, U.S.A.: Stanford, v.1922 (*Prof. G. F. Ferris*).

Two New Parasites of the Coffee-berry Scolytid.

Superfamily VESPOIDEA.

Family BETHYLIDAE.

Genus *Prorops*, nov.

♀. Head quadrate, produced anteriorly (ventrally) into a median beak, which is apically bifid and carries the toruli laterally; occiput not margined, though separated by a shortly rounded edge from vertex; eyes minutely pubescent, set low down and practically on the base of the mandible; the latter large, robust three-dentate and dependent. Antennae twelve-jointed; labial palpi with one, maxillary palpi with three joints. Pronotum campanulate; mesonotum simple; scutum only a little longer than scutellum without foveae or superficial furrows, though indications of parapsidal divisions can be made out anteriorly beneath the pronotum; propodeon simple without longitudinal or bordering carinae, a little widened in front of the laterally directed spiracles; fused prepectora forming a narrow band a little wider at each side, in front of the mesosternopleurae. Wings with a moderately long submarginal, very short marginal and long radial veins, only a trace of the anal vein at radix; no closed cell except the subcostal; hind wings without neuration, except for indications towards the radix of the subcostal and anal veins. Legs with all coxae somewhat broad and a little flattened, all femora slightly swollen; mid and hind tibial spurs double and, as on fore tibia, with frayed edges; tarsal claws simple. Abdomen with petiole short, about as broad as long, with six pairs of spiracles [segments ii (petiole and post-petiole)-vii]; the 3rd tergite shows anteriorly on each side an oblique, narrow, clear area. Ovipositor short and half the length of the second segment.

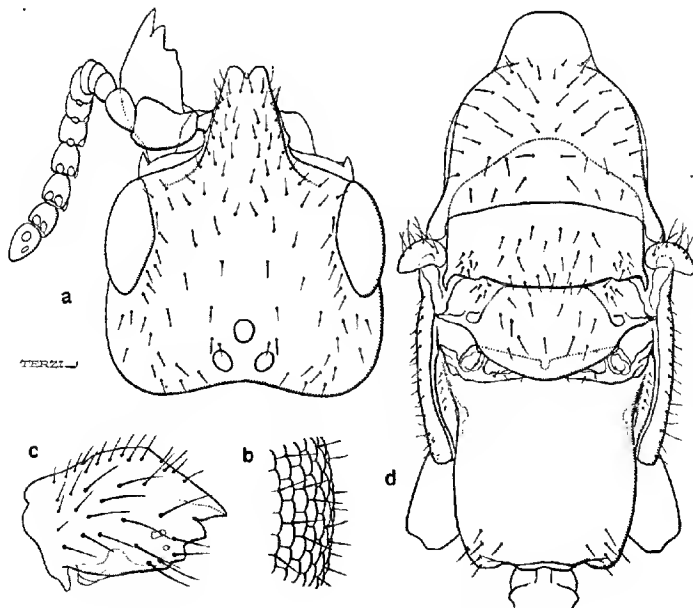


Fig. 5. *Prorops nasula*, gen. et sp. n., ♀: a, head from above; b, pubescence of eye; c, mandible; d, thorax, propodeon and hind coxae.

***Prorops nasuta*, sp. n.**

♀. A blackish brown or piceous species, with paler honey-clear scape, pedicel, trochanters, tibiae and tarsi; hind tibiae slightly darker along mid dorsal line. Forewings faintly tinted, hind wings hyaline; veins smoky brown.

Head (fig. 5, *a*), breadth and length subequal if the "snout" is taken into account, but distinctly transverse otherwise; posterolateral angles rounded; occiput re-entrant, occipito-vertical edge distinct but rounded, ocelli in equilateral triangle; eyes in length three-sevenths the breadth of the head, with the pubescence (fig. 5, *b*) very sparse and short, separated by about two-thirds the breadth; on vertex and upper frons smooth, then rugulose, and finally scaly reticulate on snout. Antennae (fig. 6, *a*, *b*) with the funicular joints, especially the more proximal, distinctly eccentric. Mandible (fig. 5, *c*) obliquely cut away distally on ventral edge; stipes triangular with up to a dozen small bristles; maxillary palpi, 2, 5, 3, apical bristle of third joint 7; labial palpi 3.

Thorax (fig. 5, *d*) with the protergum overlying nearly half the mesoscutum, completely enclosing the spiracle posterolaterally; prosternum hexagonal and truncated in front, posterior angles rounded. Propodeal spiracle small, circular. Thoracic surface dorsally nearly smooth, the pattern fine and not raised, that of metanotum and propodeon rougher and dull, the pattern distinctly raised.

Wings: forewings (fig. 6, *c*) (14:5), length 1.2-1.3 mm.; neurulation extending to just beyond two-thirds; submarginal and marginal radius, more exactly the three are in ratio 34:4:37; anal vein traceable anteriorly for a short distance from radix on its anterior margin, but practically all spurious. Hind wing (4:1), length 1.1 mm.; two hooks at four-sevenths from the radix; the longest bristles of the fringe rather less than one-third (five-eighths) the breadth of the wing, and five much longer ones (two-thirds longer than any in the fringe) on the posterior edge at the radix behind the stump of the anal vein.

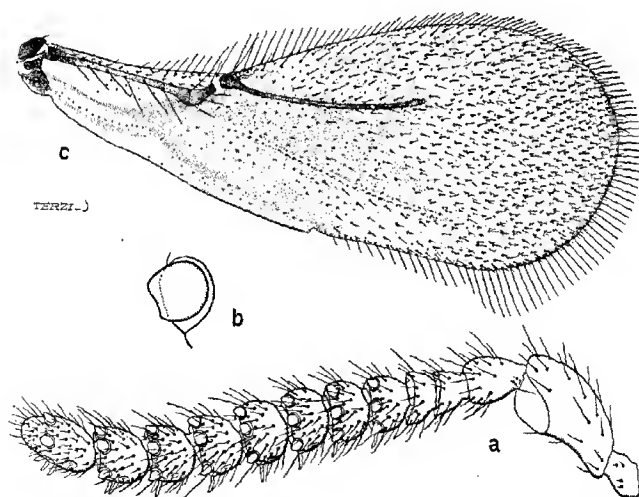


Fig. 6. *Prorops nasuta*, gen. et sp. n., ♀: *a*, antenna; *b*, middle sensorium on fifth joint of funicle; *c*, forewing.

Legs: fore legs with the coxae as broad as long, raised reticulate, with numerous hairs anteriorly, posteriorly smoother, with two hairs above trochanter; femora (14:5) more than half longer than coxae, a little longer than tibia (9:2) and subequal to tarsus; at apex of tibia posteriorly two spines (one thin) above the spur; comb of first tarsal joint with 25-27 spines; tarsus, 37:13:12:11:23. Hind legs with coxa (3:2) pear-shaped, projecting in front of its attachment; femur (5:2) one-sixth shorter than the tibia (11:2) and only two-thirds the length of the slender tarsus, the ventral fringing bristles of the tibia on the distal half spinose, and an irregular apical transverse row of similar bristles anteriorly and posteriorly above the spur, a stout spine and stiff bristle as in the other legs; longer tibial spur three-fourths the first tarsal joint measured ventrally; tarsus, 56:28:25:19:28. Mid legs, coxa (3:2); femur (5:2) just shorter than tibia (30:7) and two-thirds the tarsus; tibia with about 18 stout spines along the dorsal edge, arranged (beginning proximally) singly and doubly alternately, with the last three double; there are also some spines (3-4) below the dorsal edge on the apical fourth; tarsus 40, 21, 21, 17, 28. *Abdomen* with whole surface smooth; petiole very short, transverse (2:3) on rather more (five-ninths) than its anterior half, and across the nearly circular spiracles one-ninth wider than long; in front of the spiracles aciculate (14-15 striac); about half a dozen bristles on each side of the mid line behind the spiracles; the segments gradually decreasing, the first six being in ratio 12:11:10:10:9:8:7. The 2nd tergite has on each side a narrow pellucid area irregularly divided; sternite of petiole narrow (9:5), with an internal chitinous rod on each side; whole surface rough, strongly raised reticulate; the pellucid areas of the 2nd sternite are at the anterolateral angles. In segments ii-vii both tergites and sternites have apparently a short incision on the posterior edge on each side of the mid line, these "incisions" being really narrow unchitinised areas of the sclerites. Sheaths of the ovipositor short, bare except for a terminal tuft of short bristles (6-8).

Length about 2 mm.; alar expanse about 3 mm.

UGANDA: Najunga, 24.v.1922 (*H. Hargreaves*).

Type in the British Museum, one of 3 ♀♀ (two imperfect) bred from the coffee-berry Scolytid, *Stephanoderes hampei*, Ferr.

The complete absence of basal cells and the well-developed radius make the position of this insect a somewhat isolated one in the present classification of the family. The rostrate head is found in several groups centring round *Bethylus*, Latr., but it is doubtful whether *Prorops* falls in this section. Had the radius been shorter the genus might have been placed near *Cephalonomia*, Westw., to which the host relationship would also ally it.

Superfamily SERPHOIDEA.

Family CALLICERATIDAE.

Along with the Bethyloid just described, Mr. Hargreaves bred an interesting Calliceratid, of which, fortunately, both sexes were preserved. I have assigned this species for the present to the genus *Calliceras*, Nees, to which it runs down easily in Kieffer's monograph of the family (*Das Tierreich*, 42 Lief., p. 69, Berlin, 1914). This Uganda species seems to be quite distinct from anything hitherto described from the Ethiopian region, while amongst the Palaearctic species its nearest relatives are probably in the *trissacanthus*, Kieff., *armata*, Kieff., group. Amongst its noteworthy features are (a) the single-jointed lateral palpus (♂ ♀); (b) the peculiar thoracic spiracles; (c) from above, behind the scutellum, two teeth are plainly visible, i.e., the projecting posterolateral angles of a plate-like edge connecting the spiracles on the propodeon (fig. 7, e); in profile also the middle of the morphological metanotum ("post-scutellum") forms a short, blunt, inconspicuous tooth (fig. 7, b), this being apparently the condition indicated in descriptions where the "metanotum" is said

to be tridentate; (d) I have been unable to detect any spiracles on the abdomen of either sex, and the curious structure on tergite iv, whose effect in preventing the close application of this and the overlap of the preceding tergite can be seen in a specimen mounted in profile, may be correlated with this fact.

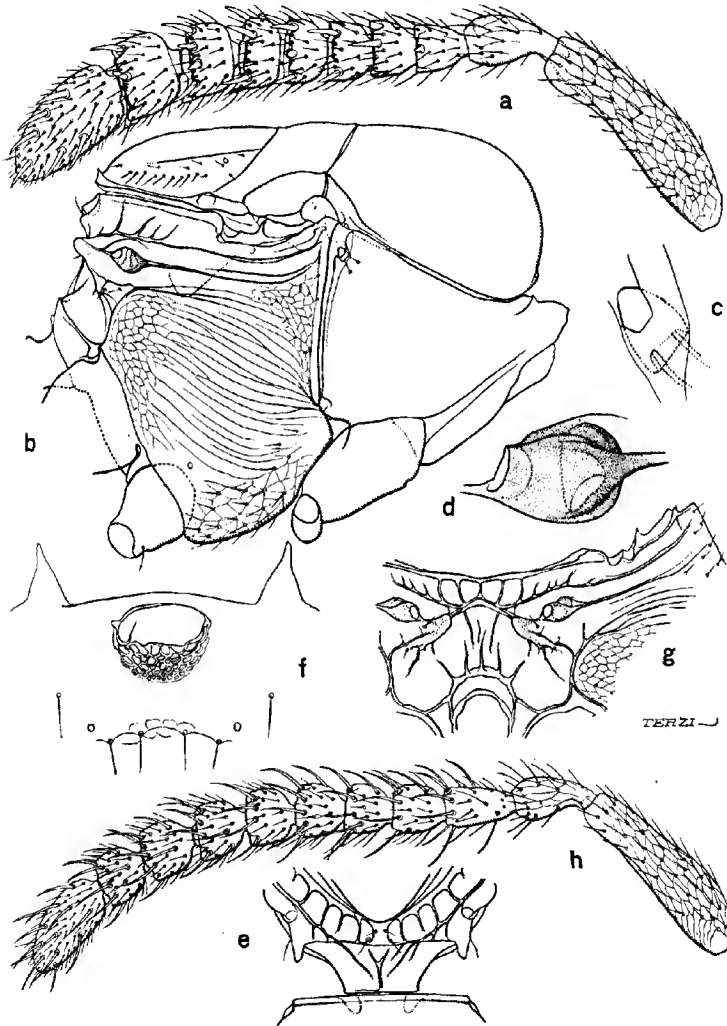


Fig. 7. *Calliceras dictynna*, sp. n.: a, antenna of ♀; b, thorax of ♀ in profile; c, prothoracic spiracle; d, propodeal spiracle; e, propodeon of ♀ from above; f, middle of fourth tergite of ♀; g, propodeon of ♂ from behind, flattened; h, antenna of ♂.

***Calliceras dictynna*, sp. n.**

♂. Black, with the following parts paler: antennae blackish brown, the scape of a lighter tone, hind coxae yellowish with a narrow blackish ring at base, and a little darker dorsally, trochanters and tibiae at base (about one-fourth) smoky yellow, all tarsi clear yellow. Wings hyaline, neuration on costa brown, radius paler.

Head with length and breadth subequal; eyes minutely pubescent, occupying five-ninths of the depth, and separated across the middle of the face by their own length; genae half as long as the eye, occiput distinctly but not carinately margined; ocelli almost in an equilateral triangle, dissimilar; the hind pair lenticular, the anterior broadly cordate; posterior ocelli separated by rather less than the distance of either from the orbit, anterior ocellus from the orbits twice its distance from either of the posterior ocelli. Pattern of head moderately fine, raised reticulate, with numerous short bristles.

Antennae (fig. 7, *h*): length 0.56 mm., eleven-jointed, hardly expanded distally, the club only one-sixth wider than the first funicular. Scape just equal to the pedicel and first two funicular joints, pedicel shorter than the first funicular, which again is exceeded by the club. Mandibles long, rather narrow from in front with two acute teeth, the lower more robust, from the outer aspect about two and a half times, from above about twice as long as broad. Stipes smooth, bare, one sensory pustule, maxillary palpi 9, 9, 10, 12 with terminal bristle 11, labium with 2 pustules, palpi 7. Six stout parallel spines in row on upper aspect of labium at each side.

Thorax: pronotum consisting of two lateral triangular sclerites narrowly united by a median collar, which is anteriorly rugulose with posteriorly a row of 5-6 foveae; side-pieces nearly smooth, with numerous (about 20) hairs on upper half, spiracle minute, thimble-shaped and entirely enclosed, situated at upper posterior (*i.e.*, morphologically the posterolateral) angle; episternites oblong, united, enclosing the sternite. Mesonotum (fig. 8, *b*) with surface and chaetotaxy as on head; mid scutal line distinct, axillary suture fused, internal; scutellum on each side with a narrow smooth flange, which under a low power looks like a line; mesopleurae striate above, reticulate below. Metanotum-propodeon (fig. 7, *g*) very short, with about four complete cells below the apex of the scutellum, formed by short rugae meeting a transverse keel, which forms a small tooth on each side; spiracle protected by a rounded knob-like projection; above the insertion of the petiole are six or seven incomplete keels.

Wings: forewings (fig. 8, *a*) (14 : 5), length 0.7 mm.; neuration extending to six-sevenths from the radix; costal vein, marginal and radius in ratio 11 : 2 : 6; post-marginal practically absent, represented by a stump only large enough to hold three clear pustules. Hind wings (about 5 : 1), length 0.6 mm.; hooks at about two-fifths from radix; neuration reduced to a minute costal stump at radix.

Legs: forelegs with coxae (3 : 2) boldly transversely striate-reticulate, with one preapical bristle; trochanters smooth; femora (10 : 3) longer (12 : 11) than tibia (5 : 1) or tarsus, which are of equal length; tibia with seven stiff parallel spines above the anteroventral edge on its distal half, two spines at posteroventral angle above the deeply frayed spur; first tarsal joint bent, with about 25 spines in comb; tarsus, 24 : 7 : 6 : 6 : 12. Mid leg with femur (4 : 1) and tibia (6 : 1) equal and just shorter than tarsus; the latter 25 : 10 : 8 : 7 : 13; tibia with 4-5 stronger spines across apex. Hind legs with coxae (2 : 1) large, trochanter swollen dorsally; femur (11 : 4) shorter than tibia, which is barely 6 : 1, and equals the tarsus; tibial comb with five spines; tarsus, 42 : 11 : 9 : 8 : 16.

Abdomen with the segments telescoped, 1st tergite much the largest (two and a half to over three times as long as the 2nd, according to the extension of the segments); all tergites and sternites smooth and shining with two, generally widely spaced, clear sensory pustules, which do not bear long bristles and with a tendency to show a faint transverse reticulation on posterior half. Tergite i with sharp straight edge anteriorly,

and on each side of the mid line above this edge a large pellucid thickening of the chitin divided indistinctly into one or two cells; beyond each of these clear areas anterolaterally is a boss with a much finer pattern and 10-12 minute stiff bristles; tergite iv with anteromedianly the remarkable reticulated chitinous ring shown in fig. 7, f; tergite vii trilobed, the lateral areas triangular, with about ten short bristles, the mid lobe forming the pygidial area (about 5 : 1) bearing the two sensory pustules, which are here closely approximated and not wide apart as on the preceding tergites, with two bristles posteriorly. Chaetotaxy: apart from the bristles already mentioned, tergite i is bare posteriorly; tergite ii bears a posterior row of four bristles (2 : 2); tergites iii-v, 4, 1, 4; tergite vi, 1, 1. Genitalia (fig. 8, c): sternite i bordered and crenulate anteriorly, with two clear areas and bosses as on the corresponding tergite, and covered with short bristles (33-35) in a posteromedian triangular patch; sternite ii with seven bristles in posterior row 3, 1, 3; sternite iii, 2, 1, 2; sternite iv-v, 2, 2; the last sternite has probably about 14 bristles.

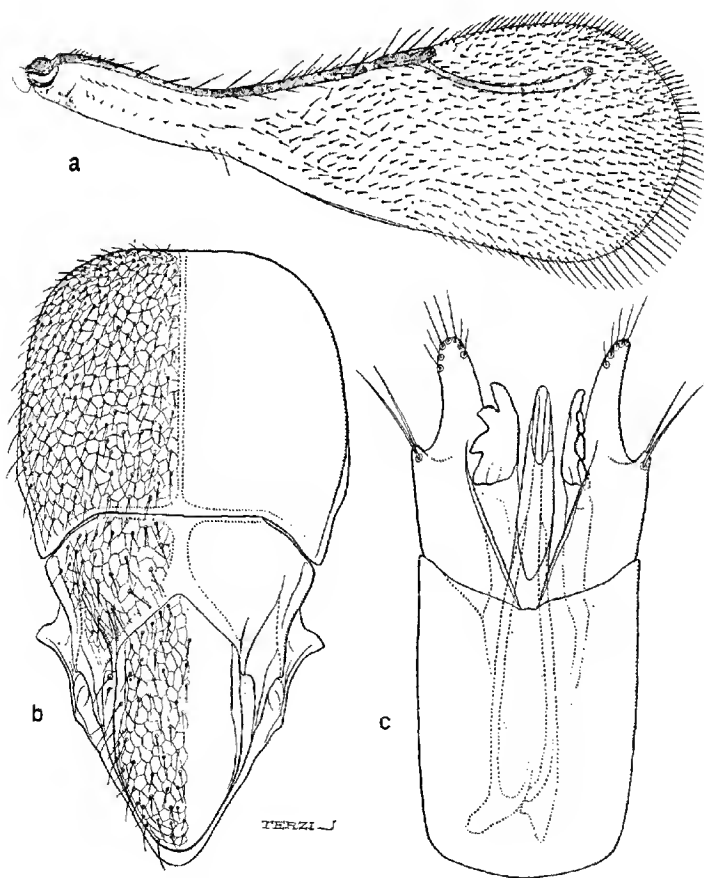


Fig. 8. *Calliceras dictynna*, sp. n., ♂: a, forewing; b, mesonotum; c, genitalia.

Length, 1 mm. ; alar expanse, about 1·6 mm.

♀. Coloured almost exactly like the ♂, but the scape of the antennae paler and almost clear yellow ; the tibiae, too, are much lighter in tone than the femora, being clear brown, obscurely paler for a short distance at base.

Similar to the ♂. Head, across vertex, transverse ; ocelli in a perfect equilateral triangle ; taking the distance between the ocelli as one, the anterior ocellus stands from the orbit at one and four-fifths, while the lateral ocelli are one and two-fifths from the orbits. Lateral teeth of propodeon more pronounced than in ♂. Forewings narrower (10 : 3) than in ♂ ; length, 0·7 mm. Legs : forelegs with femur broader (8 : 3) than in ♂ ; tibia also broader (22 : 5) ; tarsus shorter than tibia, 1st tarsal joint longer (28) ; the rest as in ♂. Mid legs with femur also broader (11 : 3) ; 1st tarsal joint longer (30). Hind legs with femur broader (about 10 : 4) ; first tarsal joint longer (46).

Length, 0·1-1·2 mm. ; alar expanse, 1·6-1·8 mm.

Type ♀ in the British Museum, one of a series (1 ♂, 3 ♀♀, and broken ♀) from *Stephanoderes hampei*, Ferr.

UGANDA : Najunga, 24.v.1921 (*H. Hargreaves*).

TSETSE-FLIES BREEDING IN OPEN GROUND.

By C. F. M. SWYNNERTON.

(Plate IX.)

As it appears to be a very unusual occurrence for tsetse-flies to breed in places entirely devoid of overhead shade, it is perhaps desirable to place on record two observations of this kind that I have made recently in Tanganyika Territory.

The first case was on an open piece of ground at the junction of *Brachystegia* and *Combretum* savannah woodlands (Plate ix, fig. 1), through which runs a game path that is just visible in the photograph reproduced. Here, in the position indicated by the native searchers and with no overhead shade whatever, a large number of puparia of *Glossina morsitans* and a few of *G. pallidipes* were found. It was a spot in which the game, returning from a water-hole close by, stopped to stand, roll and play. In open sandy ground beside the water itself a few puparia were found, but not nearly so many as I was led to expect from the fact that many game paths met there.

The second photograph (Plate ix, fig. 2) represents a churned up dust-bath used by some of the game animals. In the sand that composed it were a few puparia, their position being indicated by the stick held by a native. This photograph was taken from nearly the same spot as the first, but facing in another direction, and it is important to notice that there were five fallen logs close by under which further puparia were taken, so that it was not any lack of suitable breeding-places that made the flies drop their larvae in the open ground. I do not think that *Glossina morsitans*, at any rate, displays a great deal of forethought for its young, but the best conditions for resting females and for their puparia happen to coincide.

A point of no little importance is that a high proportion of the puparia found in the open were dead.



1.



2.

Localities in which tsetse-flies have been found breeding in the open without overhead shade.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st January and 31st March 1923, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

THE ACCRA LABORATORY :—10 Tabanidae, 172 *Glossina*, 3 *Stomoxys*, and 11 Hymenoptera ; from the Gold Coast.

Mr. T. J. ANDERSON, Government Entomologist :—3 Hymenoptera and 10 Lepidoptera ; from Kenya Colony.

Dr. G. ARNOLD :—8 Tabanidae, 102 other Diptera, 176 Coleoptera, 2 Cimicidae, and 40 other Rhynchota ; from Rhodesia.

Mr. E. BALLARD :—6 Coleoptera ; from Bristol.

Mr. P. J. BARRAUD :—10 Culicidae and 11 Coleoptera ; from Punjab, India.

Mr. C. F. C. BEESON, Forest Zoologist :—6 Lepidoptera ; from Dehra Dun, India.

Mr. G. E. BODKIN, Agricultural Entomologist, Department of Agriculture and Fisheries :—25 Siphonaptera, 19 Hippoboscidae, 117 Hymenoptera, 46 Coleoptera, 5 Lepidoptera, 2 Rhynchota, 7 Orthoptera, 11 Anoplura, 7 Mallophaga, and 114 Ticks ; from Palestine.

BOMBAY NATURAL HISTORY SOCIETY :—4 Coleoptera, 27 Lepidoptera, 2 Rhynchota, 226 Orthoptera, 5 Planipennia, and 2 Spiders ; from India.

Mr. J. R. BOVELL, Superintendent of Agriculture :—4 Diptera, 35 Hymenoptera, 3 Coleoptera, 4 Rhynchota, and 10 Mites ; from Barbados.

Dr. H. BRAUNS :—22 Diptera and 2 Coleoptera ; from Cape Colony.

Mr. A. J. BROOKS, Director of Agriculture :—40 Ants ; from Gambia.

Mr. H. BRYAN, Junr. :—3 Stratiomyidae and 2 Pentatomidae ; from Hawaii.

Dr. P. A. BUXTON :—50 Culicidae, 62 other Diptera, 18 Hymenoptera, 139 Coleoptera, 5 Lepidoptera, 74 Rhynchota, 68 Orthoptera, and 33 Mallophaga ; from Egypt and Palestine.

Dr. J. M. CLARK :—742 *Glossina morsitans*, Westw. ; from Tanganyika Territory.

Mr. L. D. CLEARE, Junr., Government Economic Biologist :—2 Culicidae, 10 other Diptera, 36 Hymenoptera, 11 Rhynchota, 4 Orthoptera, 4 Trichoptera, 10 Ephemeridae, 20 Mallophaga, and 7 Spiders ; from British Guiana.

Mr. G. H. CORBETT, Government Entomologist :—12 Rhynchota ; from the Federated Malay States.

Mr. G. S. COTTERELL :—3 *Tabanus*, 25 other Diptera, 21 Hymenoptera, 9 Coleoptera, 53 Rhynchota, 11 Orthoptera, and 2 Planipennia ; from the Gold Coast.

Dr. K. U. DAMMERMAN :—79 Coleoptera ; from Java.

Mr. M. T. DAWE :—1 Coleopterous larva and example of borings, and 2 species of Coccidae ; from Sierra Leone.

DEPARTMENT OF AGRICULTURE, Mauritius :—7 Coleoptera ; from Mauritius.

DIRECTOR OF VETERINARY EDUCATION AND RESEARCH, Pretoria :—31 Siphonaptera, 261 Tabanidae, 85 *Glossina*, 50 *Glossina* puparia, 218 Hippoboscidae, 4,407 other Diptera, 132 Oestrid larvae, 66 Hymenoptera, 393 Coleoptera, 4 Coleopterous pupae, 146 Lepidoptera, 15 Lepidopterous larvae, 18 Cimicidae, 2 species of Coccidae, 54 other Rhynchota, 84 Orthoptera, 12 Anoplura, 2 Odonata, 2 Planipennia, 2 Ant-lion larvae, 511 Ticks, 9 Spiders, 2 Centipedes, and a large number of Intestinal Worms ; from Zululand.

Mr. W. W. FROGGATT :—12 Diptera, 13 Hymenoptera, 12 Coleoptera, 10 Rhynchota, 80 Thysanoptera, and 2 species of Galls ; from New South Wales.

Mr. F. D. GOLDING :—19 Diptera, 20 Hymenoptera, 31 Coleoptera, 17 Lepidoptera, 39 Rhynchota, 3 Orthoptera, and 2 Planipennia ; from Southern Nigeria.

Dr. P. v. D. GOOT :—41 Coleoptera, 3 Lepidoptera, and 29 Rhynchota ; from Java.

Mr. C. C. GOWDEY, Government Entomologist :—2 Formicidae and 2 species of Coccidae ; from Jamaica.

Mr. W. J. HALL, Entomologist, Ministry of Agriculture, Cairo :—640 Orthoptera and 33 egg-cases ; from Egypt.

Mr. E. HARGREAVES :—188 Siphonaptera, 17 Culicidae, 3 *Phlebotomus*, 86 other Diptera, a number of Chalcididae, 22 other Hymenoptera, 23 Coleoptera, 13 Lepidoptera, 12 species of Aleocharidae, 11 Cimicidae, 5 other Rhynchota, 2 Orthoptera, 7 Anoplura, a number of Thysanoptera, and 20 Collembola ; from Egypt.

Mr. H. HARGREAVES, Government Entomologist :—28 larvae and 17 pupae of *Platyedra gossypiella*, Saund., and 2 species of Coccidae ; from Mexico.

Mr. R. H. HARRIS :—8 *Glossina* puparia ; from Zululand.

Mr. G. F. HILL :—62 Culicidae, 2 Psychodidae, a number of Chalcididae, 9 Lepidoptera, 4 Rhynchota, and 800 Isoptera ; from North Queensland.

Dr. W. HORN :—751 Coleoptera ; from South Africa and Dutch East Indies.

Mr. M. AFZAL HUSSAIN, Government Entomologist :—14 Chalcididae ; from Punjab, India.

Rev. NEVILLE JONES :—71 Coleoptera ; from Southern Rhodesia.

Dr. W. A. LAMBORN, Medical Entomologist :—70 Culicidae ; from Nyasaland.

Dr. R. E. MCCONNELL :—7 Culicidae, 1 Psychodid, and 1 Blattid nymph ; from Uganda.

Mr. C. W. MALLY :—4 Tingitidae ; from Cape Town.

Mr. G. A. MAVROMOUSTAKIS :—27 Diptera, and 3 Lepidoptera ; from Cyprus.

Mr. N. C. E. MILLER :—318 Lepidoptera ; from Tanganyika Territory.

Mr. J. C. MOULTON, Director, Raffles Museum :—9 Coleoptera ; from Singapore.

MUCAMBO COCOA ESTATE, LTD. :—3 Lepidoptera ; from Brazil.

Mr. W. H. PATTERSON, Government Entomologist :—3 species of Coccidae ; from the Gold Coast.

Mr. T. V. RAMAKRISHNA AYYAR, Assistant Government Entomologist :—4 Chalcididae ; from South India.

Mr. A. H. RITCHIE, Government Entomologist :—26 Hymenoptera, 76 Coleoptera, 11 Lepidoptera, 2 Lepidopterous pupae, and 18 Rhynchota ; from Tanganyika Territory.

Mr. H. W. SIMMONDS, Government Entomologist :—14 Diptera, 5 Chalcid preparations, 8 other Hymenoptera, 16 Coleoptera, 8 Lepidoptera, 13 Lepidopterous larvae, 5 species of Coccidae, and 10 other Rhynchota ; from Fiji Islands.

Mr. C. SMEE, Government Entomologist :—96 Hymenoptera, 281 Coleoptera, 6 species of Coccidae, 65 other Rhynchota, and 41 Orthoptera ; from Nyasaland.

Mr. HARRISON W. SMITH :—1 Phasmod ; from Tahiti.

Mrs. SWAINSON-HALL :—50 Lepidoptera ; from British Cameroons.

Dr. R. J. TILLYARD, Chief of the Biological Department, Cawthron Institute of Scientific Research :—1 species of Coccidae ; from New Zealand.

Mr. ROBERT VEITCH :—13 Hymenoptera and 7 early stages, 16 Coleoptera, 30 Lepidoptera, 6 species of Coccidae, 8 other Rhynchota, and 17 Thrips ; from Fiji Islands.

Mr. WEBB :—22 Coleoptera and 11 Rhynchota ; from United States of America.

WELLCOME TROPICAL RESEARCH LABORATORY, Khartoum :—3 Anthomyiidae and 2 pupa cases, and 214 Coleoptera ; from British Sudan.

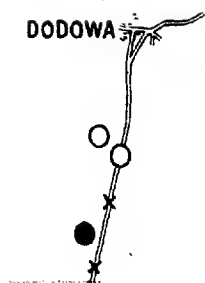
Mr. C. B. WILLIAMS, Entomologist, Ministry of Agriculture, Cairo :—66 Cercopidae, from Trinidad.

Mr. G. N. WOLCOTT :—15 Weevils ; from Porto Rico.

Mr. R. C. WOOD :—A number of Diptera, 308 Hymenoptera, 19 Coleoptera, 30 Lepidoptera, 299 Rhynchota, 21 Orthoptera, 4 Isoptera, 3 Anoplura, 4 Mallophaga, 4 Centipedes, 9 Spiders, and 2 Scorpions ; from Nyasaland.

Mr. H. W. WOOLLEY, Assistant Forest Research Officer :—6 Coleoptera and 6 Hymenoptera ; from the Federated Malay States.

G.C.Nº 20353



DESCRIPTIONS OF SOME NEW SPECIES AND SOME NEW RECORDS
OF COCCIDAE.—I. DIASPIDINAE.

By E. E. GREEN and F. LAING.

***Dinaspis veitchi*, sp. n. (fig. 1).**

Puparium of ♀ dark-greyish ochraceous, narrow in front, broadening moderately posteriorly, straight or slightly curved.

Puparium of ♂ white, tricarinate, straight.

Adult ♀ elongate, narrow in front, broadening gradually to its greatest width across the last fused segment; whole body except pygidium and the two or three free abdominal segments highly chitinised. Rudimentary antennae on small tubercles, with a long strongly bent seta and another minute one. Anterior spiracles situated well behind the mouth-parts, with numerous parastigmatic pores, posterior spiracles with a few (3-4), neither very conspicuous. Posterior free abdominal segments with numerous lateral pores and several marginal setae. Pygidium with median lobes slightly divergent, not protruding quite so far as first laterals, fan-shaped, inner margin serrated; first and second lateral lobes well developed, duplex, the second lobule in each not much smaller than the first; a gland-prominence between the median and first, and between the first and second lobes; a spiniform squama exterior to the second pair of lateral lobes, the margin beyond produced into three broad, flat, serrated prominences. Circumgenital pores absent; dorsal pores numerous, irregular. Length, 1.76 mm.; breadth, 0.58 mm.

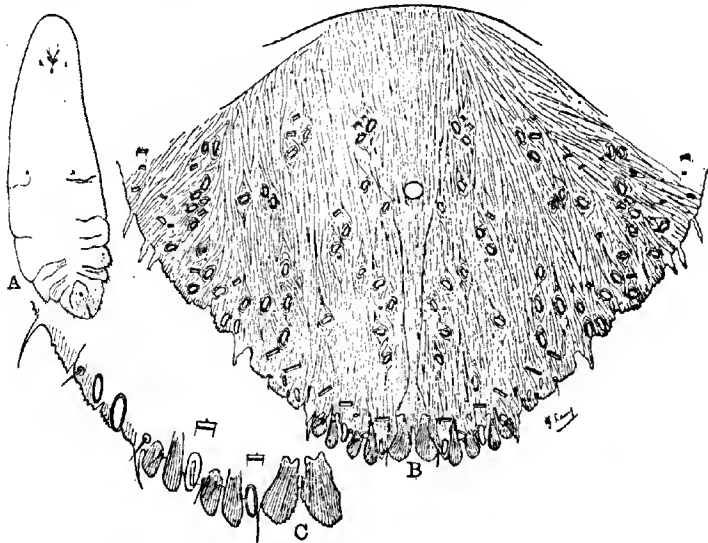


Fig. 1. *Dinaspis veitchi*, sp. n.: A, adult, ♀ × 29; B, pygidium, × 350; C, margin of pygidium, × 490.

FIG1: Rarawai; on stem of an unknown plant (*R. Veitch*).

Near to *Dinaspis flava* (Green), a Ceylonese species, but differing from the latter, apart from the colour of the ♀ puparium, in that the median lobes in *D. flava* are more recessed.

***Pinnaspis pattersoni*, sp. n. (fig. 2).**

Puparium of ♀ white, exuviae pale yellow, mussel-shaped, very often broadened posteriorly, curved or nearly straight. Length, 1.5-2.5 mm.

Puparium of ♂ not observed.

Adult ♀ narrow in front, widening posteriorly to a little in front of the pygidium, where it reaches its greatest width, about three-sevenths the length. Antennae consisting of a tubercle with two curved setae. Anterior spiracles with a small group of parastigmatic pores. Venter of thorax and basal abdominal segments with small groups of broadly conical thorn-like processes. Pygidium without circumgenital pores; median lobes relatively large and prominent, conspicuously bicuspid, closely fused together; lateral lobes ill-defined, represented by more densely chitinised marginal prominences in the usual positions (the area comprising the median and first lateral lobes often more heavily chitinised than the surrounding area). Squamae spiniform, one immediately exterior to the median lobes, a second and third shortly beyond the prominences that represent the two lateral lobes, and a pair nearer the base of the pygidium. Two conspicuous series of from 7-9 large dorsal pores on each side, on the basal half of the pygidium, and single pores (or short series of 2 or 3) at intervals along the margin. Length, 1.0-1.14 mm.

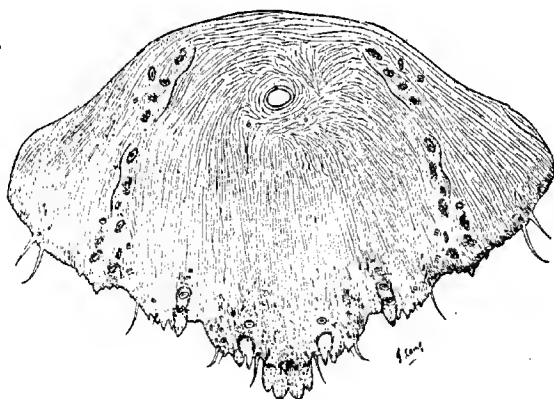


Fig. 2. *Pinnaspis pattersoni*, sp. n., pygidium of ♀, ×205.

GOLD COAST: Aburi; on bark of *Rauwolfia vomitoria* (W. H. Patterson).

Near to *Pinnaspis chionaspiformis* (Ncwst.), from which it may be distinguished by the shape of the pygidial margin and the absence of circumgenital pores. It is the only species of *Pinnaspis* known in which such pores are not present.

***Florinia* (*Adiscoforinia*) *pygosema*, sp. n. (fig. 3).**

Puparium of ♀ shining black, linear, more or less parallel-sided, sometimes slightly curved, attenuated both anteriorly and posteriorly. Length, 0.9 mm.; breadth, 0.25 mm.

Adult ♀ about three times as long as broad. Rudimentary antennae composed of two slightly curved setae situated on small tubercles. No interantennal tubercle. No parastigmatic pores. Pygidium with circumgenital pores lacking and the apical

margin produced into six long slender-pointed processes, the median pair about one-third shorter and fused at the base, with a short conical process in the first interval and two in the second interval. Length, 0.62 mm.

TANGANYIKA TERRITORY: on sea-coast south of Dar-es-Salaam, on leaves of an unknown plant of the mangrove type growing at high-water mark (A. H. Ritchie).

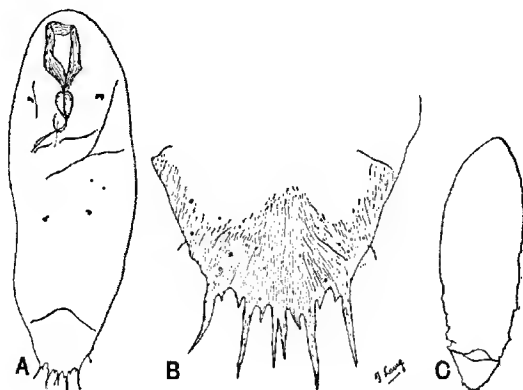


Fig. 3. *Fiorinia pygosema*, sp. n.: A, adult ♀, $\times 100$; B, pygidium of same, $\times 350$; C, puparium of ♀, $\times 42$.

***Aspidiotus pangoensis*, Doane & Ferris.**

FIGI: Macuata Is.; on trunk of coconut palm, 10.v.1921 (H. W. Simmonds).

***Aspidiotus (Aonidiella) ritchiei*, sp. n. (fig. 4).**

Adult ♀ of the usual turbinate shape, the whole rather strongly chitinised and rigid; pygidium slightly retracted; margin minutely crenulated, the crenulations becoming wider on the abdominal segments. Pygidium with median lobes low and rounded, the second and third lobes broader than long, rounded, a fourth lobe also

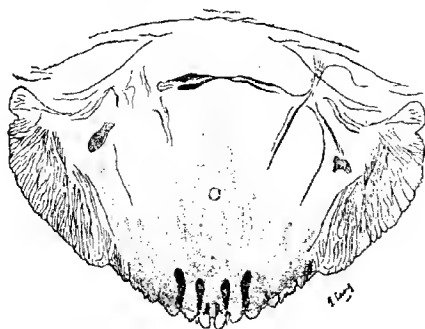


Fig. 4. *Aspidiotus (Aonidiella) ritchiei*, sp. n., pygidium of adult ♀, $\times 205$.

present in the form of a wide 4-serrated projection. Squamae very minute and inconspicuous in the intervals between the lobes. Paraphyses in three pairs, the median pair very short, springing from the inner margin of the median lobes; the second and third pairs longer and stouter, situated immediately beyond the median and first lateral lobes respectively. Circumgenital and dorsal pores absent. A broken series of chitinous bars across the base of the pygidium. Length, 1.2 mm.; breadth, 1.1 mm.

JAMAICA: Kingston; on the bark of *Cassia fistula*, in company with *Aspidiotus herculeanus*, Doane & Hadden (A. H. Ritchie).

***Aspidiotus (Aonidiella) multiclavata*, sp. n. (fig. 5).**

Puparium of ♀ subcircular, flattish or very low convex, black, covered with a whitish deposit, except for the subcentral nipple, which, as a rule, is left black. Diameter, 1.6 mm.

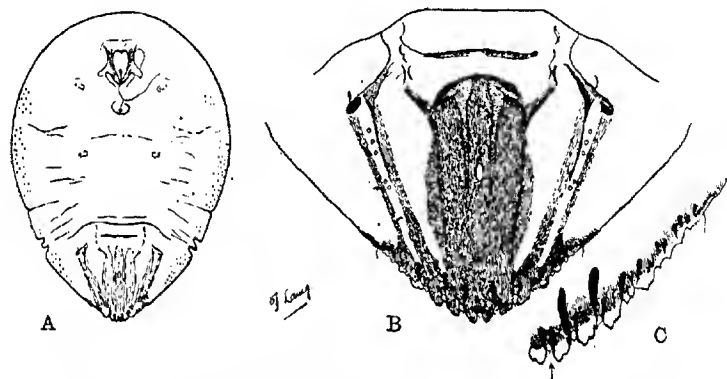


Fig. 5. *Aspidiotus (Aonidiella) multiclavata*, sp. n.: A, adult, ♀ $\times 42$; B, pygidium of same, $\times 205$; C, margin of pygidium, $\times 290$.

Adult ♀ ellipsoidal, attenuated posteriorly, the pygidium demarcated by a lateral notch. Antennae consisting of a tubercle with a moderately long, curved seta. Spiracles with inner opening flared, with no parastigmatic pores. Pygidium with four pairs of lobes, the median pair slightly smaller than the others; all of approximately the same form, with a prominent rounded or subacute cusp placed near the inner side, the outer side sinuous or obscurely serrate. Margin immediately beyond the outer lobe with three or more sharply pointed prominences. Two similar prominences between the third and fourth lateral lobes, and a smaller point in each interval between the other lobes. A pair of conspicuous stout paraphyses in each interval between the lobes; those in the interval between the median lobes relatively short and of approximately equal size; those in the next two intervals of unequal size, the inner one of each pair fully twice as large as the outer one; four or more relatively small paraphyses on the jagged area of the margin beyond the outer lobe. Some very minute and inconspicuous squamae in the intervals between the lobes, and the usual marginal setae minute and inconspicuous, except for one shortly beyond the jagged area of the margin. No circumgenital pores. Dorsal pores few. Anal orifice approximately central, relatively small, narrowly ovoid. Length, 0.94 mm.; breadth, 0.78 mm.

JAMAICA: Hill Gardens; on redwood tree (*Erythroxylon areolatum*) (C. O. Gowdey).

***Pseudaonidia iota*, Green & Laing.**

Through the kindness of Mr. Harold Morrison, U.S. Bureau of Entomology, we have been enabled to see a photograph of the pygidium of *P. clavigera*, Ckll., taken from the type material. There is no doubt but that *P. iota* is a synonym of Cockerell's species. We were misled by the original description of *clavigera*, in which Cockerell states quite positively that there are no circumgenital pores present, and Brain in his re-description of that species (Bull. Ent. Res., ix, p. 207) repeats the mistake. Examination of material of *P. clavigera* from S. Africa shows the presence of circumgenital pores clearly.

***Pseudaonidia subtesserata*, sp. n. (fig. 6).**

Puparium of ♀ brownish grey, subcircular to ovate, low convex; exuviae concealed, eccentric. Length, 2.2–5 mm.; breadth, 1.5–2 mm.

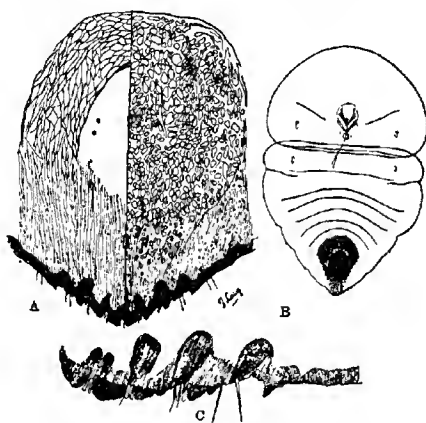


Fig. 6. *Pseudaonidia subtesserata*, sp. n.: A, pygidium of ♀, $\times 135$; B, adult ♀, $\times 28$; C, margin of ♀, $\times 325$.

Adult ♀ of the typical form of the genus, with a deep constriction behind the cephalothoracic area (at the junction between the pro- and meso-thorax). The whole insect strongly chitinated and rigid. Anterior spiracles with a small group of parastigmatic pores. Pygidium with a large tessellated area on dorsum, the areoles small and of irregular size and shape; with three pairs of broad lobes, the median pair with the tip rounded and thence shallowly, outwardly oblique and slightly sinuate; the second and third pairs more or less deeply incised at a point beyond the middle; with a short but broad paraphysis exterior to each lobe; the margin immediately exterior to the third paraphysis produced into a strong chitinous tooth; with small ligulate squamae in the intervals between the lobes; with paired setae in the usual positions, those beyond the outer lobe considerably longer and stouter; margin between and for some distance beyond the lobes deeply and densely incrassate. No circumgenital pores. Dorsal pores rather numerous on the submarginal area, but minute and inconspicuous. Length, 1.5–1.75 mm.; greatest breadth (across mesothoracic area), 1–1.5 mm.

JAMAICA: Hill Crest; on gungo (Congo) peas (C. C. Gowdey).

Near *P. tesserata*, d'Emm., from which it may be distinguished by the shorter and broader paraphyses.

***Aspidiotus (Targionia) prionota*, sp. n. (fig. 7).**

Puparium of ♀ low convex, subcircular, brownish black to black around the margins, which are hard and thick, with the centre pale yellowish grey, of a thin papery consistency.

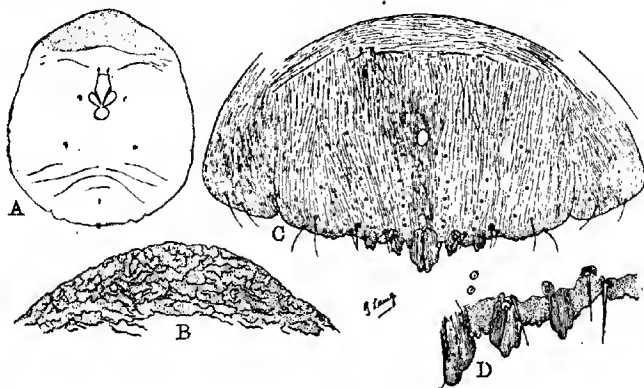


Fig. 7. *Aspidiotus (Targionia) prionota*, sp. n.: A, adult ♀, $\times 42$; B, front of head, $\times 205$; C, pygidium of ♀, $\times 205$; D, margin of pygidium, $\times 490$.

Adult ♀ subcircular, narrowed anteriorly. Cephalic region strongly chitinated, irregularly and markedly rugose. Pygidium wide but shallow, median lobes closely apposed but distinct, strongly notched on outer margin, prominent, their length a little greater than the combined breadth; two pairs of lateral lobes each strongly notched on outer margin, almost bidentate, the second pair rather smaller than the first. No squamae, a strong seta between the first and second pairs of lobes, two immediately exterior to the second pair, and several on the lateral margin. No circumgenital pores; a few minute circular dorsal pores; dorsal surface finely striated or reticulated. Length, 0.86 mm.; breadth, 0.8 mm.

TANGANYIKA TERRITORY: Ngerengere; on the bark of an undetermined forest tree (A. H. Ritchie).

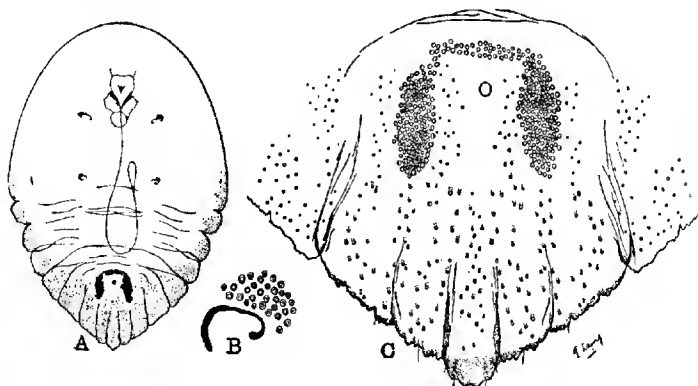


Fig. 8. *Odonaspis saccharicaulis*, Zehnt.: A, adult ♀, $\times 42$; B, anterior spiracle, $\times 205$; C, pygidium of ♀, $\times 205$.

Odonaspis saccharicaulis, Zehnt. (fig. 8).

This species was reduced by Cockerell to a variety of his *O. secreta*. If we are correct in our determination of material on sugar-cane from San Thomé (F. W. Urich), *saccharicaulis* differs from *secreta*, apart from the lateral groups of circumgenital pores being united at their base by a double to treble row of pores, in that the anterior and posterior groups of parastigmatic pores are much larger in *saccharicaulis*, the anterior having over 30, and the posterior about 20; the median lobe is broader in proportion than that found in *secreta*, and is more truncate at the apex and often slightly indented.

Aonidia truncata, sp. n. (fig. 9).

Puparium of ♀ circular or subcircular, highly convex; shining black; larval exuviae fulvous, central; fresh examples bearing several long, curling, glassy filaments; the nymphal exuviae weakly chitinised, occupying the whole space of the puparium, but concealed beneath the dense black secretory covering. Ventral scale thin, adhering to the leaf. Diameter averaging 0.5 mm

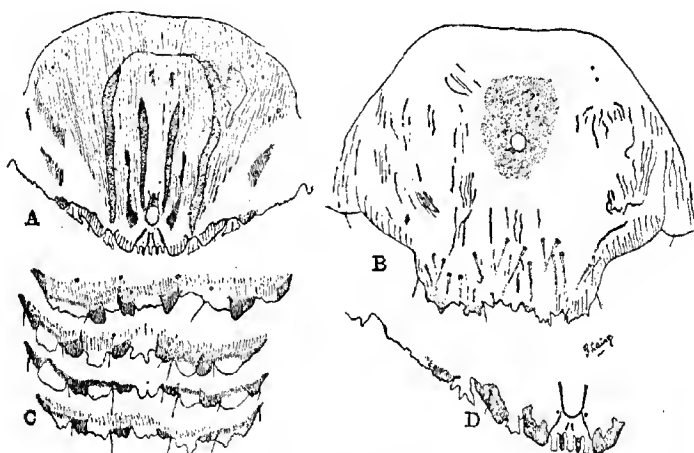


Fig. 9. *Aonidia truncata*, sp. n.: A, pygidium of nymph, $\times 205$; B, pygidium of adult ♀, $\times 205$; C, variations of pygidial margins of adult ♀, $\times 350$; D, pygidial margin of nymph.

Adult ♀ subcircular, the pygidium recessed in the dried insect, but slightly projecting after preparation, the posterior margin squarely truncate. Mouth-parts large and densely chitinised. Rudimentary antennae with one stout curved seta on the outer side, and a smaller more slender seta on the inner side. Spiracles without parastigmatic pores. Pygidium with a more or less pronounced, broad median recess; two pairs of moderately broad but short lobes, rather weakly chitinised, their free margins variously indented; the median pair separated by more than their own breadth, situate within the median recess, with two small prominences between them; the lateral pair projecting beyond the median lobes; the margin immediately exterior to each lobe produced into an irregularly quadrate, variously indented, prominence. There is a stout seta immediately exterior to each of the median lobes; a second smaller seta outside the lateral lobes, and a third

pair on the lateral margins of the pygidium, which are slightly incrassated. Anal orifice approximately central, surrounded by a more heavily chitinised circumscribed area. Dorsal pores minute, few and inconspicuous. Length and breadth approximately equal: 0.5 mm.

Pygidial margin of nymph with a pair of minute, slender, cylindrical median lobes, and two (or possibly three) pairs of broad, irregularly quadrate, lateral lobes, the second pair considerably the broadest. A ligulate, fimbriate squama in the interval between the median lobes; a similar squama between the median and first lateral lobe; a much larger, irregularly dentate, squama between the first and second laterals; and a still larger one, of the same form, between the second and rudimentary third laterals. Anal orifice at a distance from the margin scarcely greater than its longer diameter. A slender paraphysis unites the inner edge of each of the first lateral lobes with the posterior margin of the anal orifice and thence extends far inwards. Length, 0.48 mm.; breadth, 0.44 mm.

QUEENSLAND: Magnetic Island; on leaves of an unknown plant (*G. F. Hill*).

The female puparium is peculiar, in that the nymphal exuviae are not exposed, as in most species, but are concealed beneath a dense secretory covering.

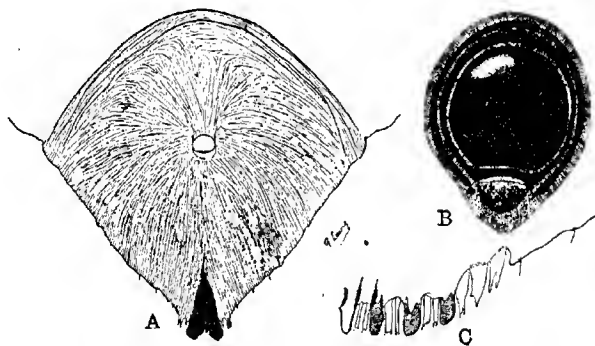


FIG. 10. *Gymnaspis bilobis*, sp. n.: A, pygidium of adult ♀, $\times 205$; B, nymph, $\times 50$; C, nymphal fringe, $\times 490$.

***Gymnaspis bilobis*, sp. n. (fig. 10).**

Puparium of ♀ consisting of the incrassated nymphal exuviae alone. It is of a broadly ovoid form, bluntly pointed behind; the median area strongly and roundly convex, the marginal area flattened. Viewed by transmitted light, the marginal area is seen to be zoned by alternately darker (thicker) and paler (thinner) concentric bands, and there is a sharply defined, obtusely triangular, area in the centre of the pygidium. Pygidial margin with three pairs of narrow, prominent lobes; with two ligulate squamae in each interval between the lobes, and three broader squamae immediately beyond the outermost lobe; all the squamae irregularly fimbriate or excised at their distal extremities. Length, 0.5-0.7 mm.

Adult ♀ turbinate, anteriorly almost as broad as long, tapering posteriorly to a point. Antenna composed of a small tubercle with a long curved seta. Pygidium with a single pair of prominent median lobes; their inner extremities narrowed and produced far within the margin; their free extremities irregularly notched; a pair

of slender squamae between the lobes and two or three spiniform squamae immediately exterior to the lobes. Length slightly more and breadth slightly less than 0.5 mm.

TANGANYIKA TERRITORY: on sea-coast south of Dar-es-Salaam; on a plant of the mangrove type growing at high-water mark (*A. H. Ritchie*).

***Lepidosaphes (Cocomytilus) lantanae*, sp. n. (fig. 11).**

Puparium of ♀ dirty white to pale yellowish brown, exuviae bright reddish brown, typically mussel-shaped or contracted and broadened posteriorly.

Puparium of ♂ white, more or less parallel-sided, exuviae fulvous.

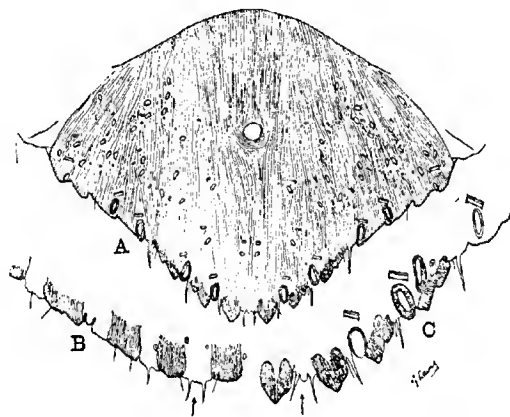


Fig. 11. *Lepidosaphes (Cocomytilus) lantanae*, sp. n.: A, pygidium of adult ♀, $\times 205$; B, abnormal form of pygidial margin, $\times 350$; C, normal form of same, $\times 350$.

Adult ♀ elongate, slightly narrowed anteriorly, widest across the base of the abdomen. Rudimentary antennae with 5-6 setae, three of which are longer and stouter than the remainder. Anterior spiracles with a small group of usually four parastigmatic pores. Pygidium without circumgenital pores; median lobes prominent, slightly divergent, almost as broad as long, separated by a space approximately equal to their breadth, inconspicuously shouldered on each side; first lateral lobes duplex, the two lobules in close apposition, the outer lobule about half the size of the inner one, each with a pointed apex and with the free margin either entire or very inconspicuously notched; second lateral lobes broad and shallow, conspicuously bicuspid. The space between the median lobes with two spiniform squamae and a small median prominence; a single spiniform squama immediately exterior to each lobe; no squamae on the basal area of the margin. Marginal pores large and conspicuous, in the usual positions; dorsal pores smaller, numerous. Length, 1.25-2 mm.; breadth (across base of abdomen), 0.5-0.8 mm.

In some examples the pygidial lobes appear to be blunted and sunk within the margin. This effect is partly due to uneven pressure during preparation, causing one surface to slide over the other.

ARGENTINA: Posadas; on *Lantana* sp. (Verbenaceae), ex coll. T. D. A. Cockerell (Coll. No. 2521).

THE BIONOMICS OF THE WHITE COFFEE-LEAF MINER, *LEUCOPTERA*
COFFEELLA, GUÉR., IN KENYA COLONY. (LEPIDOPTERA,
LYONETHIDAE.)

By HAROLD E. BOX, F.E.S.

(Published by permission of the Director of Agriculture, Kenya Colony.)

The writer was able to make a field and laboratory study of *Leucoptera coffeella*, Guér. (white coffee-leaf miner) when serving as Entomologist in Kenya Colony.

Dr. G. A. K. Marshall, C.M.G., F.R.S., and Dr. L. O. Howard, Chief of the Bureau of Entomology, Washington, very kindly assisted in supplementing the scanty literature at first available by sending to the writer most of the more important papers on this moth. Messrs. A. H. Ritchie and H. Hargreaves, Government Entomologists in Tanganyika Territory and Uganda, respectively, helped with information on the distribution, etc., of this leaf-miner in their countries.

Mr. T. J. Anderson, Chief of the Division of Entomology, Kenya Colony, gave many valuable hints and criticisms during the progress of this work. Mr. J. H. Durrant, of the British Museum (Natural History), has kindly helped with the literature relating to the nomenclature of this insect, and has also corrected the original MS.; the writer has thus been able to avoid some errors that would otherwise have occurred owing to lack of access to a good library. The black and white drawings accompanying the letterpress were executed by Mr. H. M. Loeter, draughtsman to the Department of Agriculture, Kenya Colony, who has taken great pains to ensure accuracy.

Historical.

Several adult specimens of this species were identified, through the Imperial Bureau of Entomology, by Mr. E. Meyrick, as *Leucoptera coffeella*, Guér., and are now in the British Museum, where examples from Africa were hitherto lacking.

The white leaf-miner of coffee, so far as the writer knows, was first mentioned, in 1842, by Guérin-Méneville and Perrottet (1), in a paper dealing with coffee pests in the Antilles, under the name *Elachista coffeella*. In 1858, Stainton (4) referred to this species as *Bucculatrix* sp., but in 1861 (6) placed it in the genus *Cemiosoma*, Zeller (1848). In 1895, Meyrick* adopted *Leucoptera*, Hübner (1826), in lieu of *Cemiosoma*, Z., in which he has been followed by Lord Walsingham (14), who was the first to refer *coffeella*, Guér., to *Leucoptera*.

Without doubt the most descriptive English name is that here adopted, viz., the "white coffee-leafminer," first proposed by B. Pickman Mann (8) in 1872.

In a paper by P. Madinier (7), of which very few copies are in existence (there is one in the British Museum, Nat. Hist.), on coffee culture in Rio de Janeiro, this insect is referred to as "*noctuella*."

In Mexico it was known by O. Tellez (19) as "el gusano de las hojas del cafeto," which name is accurate as regards the habits of the larva, but not descriptive of the adult.

* Meyrick, E.—"Handbook of British Lepidoptera," p. 754 (1895).

Distribution.

From references in literature, the following world-distribution of *L. coffeella* has been compiled: Mexico, Guatemala, West Indies (Trinidad, Martinique, Dominica, Porto Rico, and Cuba), Venezuela, Brazil, Ceylon (recorded by Giard, 15), Réunion, Mauritius, Arabia, Uganda (Buganda Province), Kenya Colony, Tanganyika Territory, and Madagascar. No records have been found of its occurrence in India.

In Kenya the insect may be said to occur wherever coffee is grown, although on the occasion of the writer's visit to an isolated coffee plantation in the Teita Hills (4,500 feet), in November 1921, no trace of the leaf-miner was apparent.

In the Annual Report of the Department of Agriculture of Kenya Colony and Protectorate for 1919-20 (33), Mr. A. le P. Trench, Senior Coffee Officer, gives, in a table headed "Abstract of Coffee Reports," useful information regarding the distribution of the white coffee-leaf miner within the Colony, which may be summarised as follows:—

TABLE I

Districts.	Total acreage.	No. of plantations inspected.	No. of plantations with leaf-miner.
Kyambu	3,894	36	19
Nakuru	436½	16	4
Songhor	1,118	12	6
Fort Ternan and Lumbwa	715	11	—
Nyeri	919½	11	11
Thika	991	7	—
Ulu	347	8	7
Koru	979	9	9
Nairobi and Parklands	23½	9	5
Ngong	260	3	1
Limoru	70	1	—
Totals	9,753	123	62

Mr. Trench states in the same report that the "leaf-miner moth is more or less general throughout the coffee-growing districts, there being very few plantations not affected."

Description.

THE IMAGO (figs. 1, 2).

Head with long white hair-scalps above, face deflexed, smooth; silvery white. *Thorax* silvery white. *Antennae* in repose reaching nearly to the end of the abdomen; the basal joint enlarged, clothed with white scales, the next joint also white, the succeeding joints brownish. *Palpi* 3-jointed, minute, concealed in the scaling of the face; apical joint ovoid, with five setae. *Tongue* swollen at the base, flattened, yellowish. *Eyes* large, black, scarcely visible from above, facets comparatively large. *Legs* white, clothed with long white hairs; the basal half of each tarsal joint fuscous. *Forewings* long and narrow, broadest in middle, silvery white; with a conspicuous raised tornal "eye-spot," its centre blue or purple, surrounded by a black ring margined by yellow; this again is partly surrounded outwardly and above by yellow, which is produced a short distance inward, forming a hook-shaped marking; at half the length of the costa a narrow yellow band, bordered with black, extends obliquely to the base of the yellow hook-shaped line, and is followed by a

similar oblique yellow band, arising half-way between it and the apex and reaching to the eye-spot; apex of wing with three rows of yellowish cilia tipped with black. *Expanse*: ♀ (average of 10 specimens), 6.5 mm.; ♂ (average of 10 specimens), 5.75 mm. *Hindwings* long and narrow, broadest at base, brownish, with long cilia. *Abdomen* yellowish, sparsely clothed with white scales; genitalia protected by a tuft of white hair-scales. *Length of body*: ♀ (average of 10 specimens), 2.25 mm.; ♂ (average of 10 specimens), 2 mm.

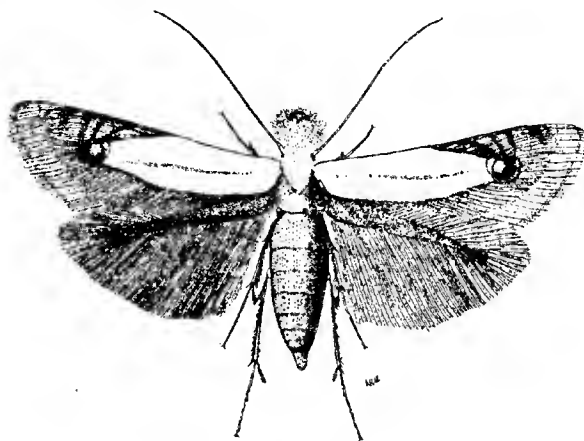


Fig. 1. *Leucoptera coffeella*, Guér.

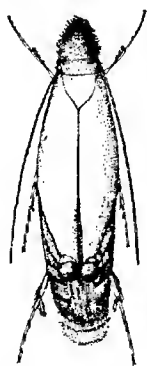


Fig. 2. *Leucoptera coffeella*
in resting position.

When the moth is at rest the wings are folded together, not overlapping (fig. 2), and the eye-spots contiguous; the forelegs projecting in front at the sides of the head, the other legs as in the figure. The antennae are concealed by the wings.

THE EGG.

The egg (fig. 3) is of peculiar structure, the top being boat-shaped, with a few indefinite radiating ridges. It has concave sides which broaden out gradually to form the "basal plate," which is oval, the ratio of length to breadth being as 2:1.5. The sides are reticulated with a fine rhomboid pattern, which extends to the edge of the basal plate. The colour of the egg, as seen by transmitted light, is pale yellow.

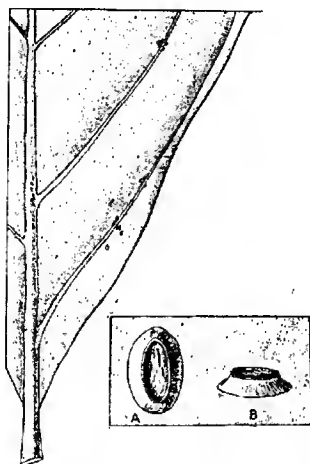


Fig. 3. Portion of coffee leaf, showing eggs of *L. coffeella*: A, dorsal view of egg; B, lateral view of egg.

THE LARVA.

The newly hatched larva is almost transparent, but soon assumes a greenish tinge, due to undigested food in the alimentary canal; in length it measures about 0.3 mm.

The full-grown larva (fig. 4) is moniliform, flattened, pale yellow, with the alimentary canal visible throughout; length about 4.5 mm., broadest at the prothorax.

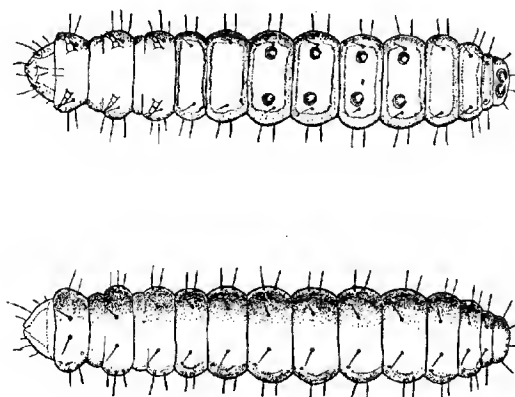


Fig. 4. Larva of *L. coffeella*, dorsal and ventral views.

From the mesothorax to the 8th abdominal segment it is of even breadth; the 9th and 10th segments gradually tapering, the posterior end of the larva being broadly rounded (figs. 5, 6); intersegmental indentations rather deep. Head (fig. 7) small,

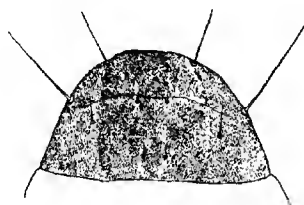


Fig. 5. Tenth abdominal segment of larva, dorsal view.

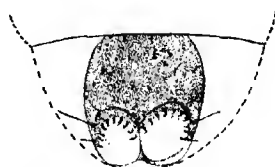


Fig. 6. Tenth abdominal segment of larva, ventral view.

flat, thickest at vertex, with the greater part of the posterior end embedded in the prothorax; antennae small but conspicuous in cleared preparations, setose. Many preparations of heads have been examined, but on each side of the head only three ocelli have been observed in each instance, the posterior being the largest, and situated pleurally. The other two ocelli are situated behind the base of the antennae, and are closely approximated to each other.* Mandibles large, with one large tooth overlapping two smaller teeth. Thoracic legs not contiguous (fig. 8), 3-jointed, setose, bearing at apex a large claw directed inward. Prolegs borne on abdominal segments 3, 4, 5, 6 (ventral) and 10 (anal). Ventral prolegs each with from 12-16 crotchets arranged in an (apparently) interrupted circle, the interruption occurring at the innermost point. Anal prolegs each with 10 large crotchets arranged in a semicircle anteriorly. The prolegs of this caterpillar seem to be almost sessile, that is to say, the crotchets are only slightly lower in situation than the ventral surface of the segments on which they are borne.

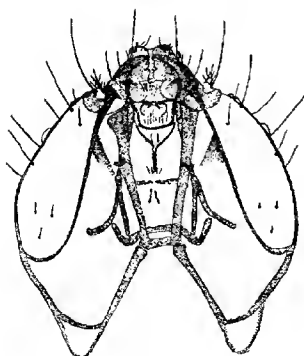


Fig. 7. Head of larva.

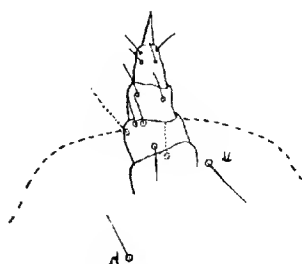


Fig. 8. Thoracic leg of larva, dorso-lateral aspect.

* Guérin⁽¹⁾ figures four ocelli of equal dimensions.

THE PUPA.

The pupa (fig. 9) is at first pale yellow, very slightly greenish, turning to light brown when the moth is about to emerge. Thirteen segments are visible from above, the largest being the mesothorax. Head broader than long; eyes small, black; antennae and legs fused together ventrally. Surface of wing-cases very finely crinkled. No process has been noticed on the anal segment in either sex. Length (average of 10 specimens), 2.25 mm.

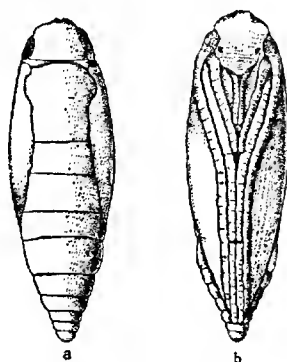


Fig 9. Pupa of *L. coffeella*: a, dorsal view; b, ventral view.

The living pupa is surrounded by a closely woven cocoon of silk, which is spindle-shaped, and dirty white in colour; it lies beneath two layers of spun silk, the first of which is oblong, with the longer edges attached to the leaf at the sides of the cocoon. The upper layer of silk is constructed in two halves, both broad arcs, touching each other at their convex edges; the ends are left open, and the points of the white cocoon project slightly. The upper silken layer, forming a roof, is pure white, and is accurately figured by Guérin (1). Average measurements of the upper silken layer are as follows: length, 6.5 mm.; breadth, 2.5 mm.; and of the layer immediately above the cocoon: length, 4.0 mm.; breadth, 1.75 mm.

Life-history.

At Kabete Entomological Laboratory (altitude about 6,000 feet), the complete life-cycle of *L. coffeella* was worked out, in one experiment only. The following account of the habits of the insect was compiled from this experiment, supplemented by others, and by continuous field observations carried out from early in December 1921 until May 1922.

Owing to the subtropical climate of the districts in which coffee is grown in Kenya, there is every reason to believe that the broods are continuous throughout the year, there being no "dormant" period, such as that recorded by Cook (18) as occurring in Cuba. The writer has been able to find all stages of the insect at any time during the period of his studies, but occasionally one of them would predominate, owing probably either to local meteorological conditions or to the incidence of natural enemies. These factors did not receive the attention they warrant owing to pressure of routine work in the Laboratory. Nevertheless, certain facts have been elucidated, and the writer's present object is to make a statement of these without comment.

In the field the moths emerge from the pupa generally in the morning, soon after sunrise. After emergence they seek a leaf in a sheltered part of a coffee tree and rest on its lower side until dusk, when they commence to fly about in search of a mate. The flight is typically short, and seldom straight, the moths flying in a series of jerks in a zigzag direction. The males fly more than the females, and after a mate has been secured the moths remain *in copula* until after dark. Light-traps put into the field at dusk caught moths in large numbers, but about 80 per cent. were males. At ten o'clock p.m. the percentage of males was about the same. When disturbed from their resting places, the pairs may either drop to the ground, remaining *in copula*, or the male will fly to a neighbouring tree, while the female drops to the ground.

Field observations at night showed that oviposition goes on for several hours after dark. Under laboratory conditions, eggs were laid by a female, hitherto virgin, within a few hours after the introduction of a male.

Of large numbers of eggs laid in the insectary, only about 4 per cent. were on the lower surface of the leaves. In the field eggs have only been found on the upper leaf surface. The eggs are laid in batches; the average number in a batch, calculated from an examination of over 200 lots on coffee leaves collected in the field, has been found to be seven, extremes being 1 and 15. In captivity, one female laid 21 eggs in one cluster when isolated with a shoot bearing six leaves. This female also laid three eggs on another leaf, two together and one isolated. Gowdey (30) has recorded the greatest number of eggs, revealed by abdominal dissection, to be 12, in Uganda. Counts of eggs laid by any one moth at Kabete showed a variation between 16 and 24.

Egg-laying under laboratory conditions occupied several days, and in more than one instance the adult female was kept alive for eight days in captivity, and laid eggs during the first two days, but after another male had been put with it, more eggs were found. This longevity was obtained only when the moths were fed on dilute syrup. No male lived for more than three days under the same conditions.

The length of the egg stage was found to vary from 7 to 12 days. Eggs exposed to the sunlight hatched invariably in less time than those kept in permanent shade. Many eggs collected in the field took ten days before hatching, the date when they were laid being unknown. In the Insectary the egg stage varied considerably, but the governing factors were not ascertained.

The first intimation that an egg has hatched is that the leaf-surface immediately below the egg becomes light green, and this minute blotch, if opened, reveals the newly hatched larva situated in the parenchymatous tissue of the leaf. As the larva continues to feed, the epidermis immediately above the destroyed parenchyma turns yellowish, then brown, and eventually forms a brittle scab, easily jerked off when that part of the leaf is bent. The mine of one larva is generally almost circular in shape, but in the majority of cases the larvae congregate to form a common mine, in which case each larva inhabits its own "arm" or ramification of the blotch. When the blotch is very large, the lower epidermis becomes discoloured. Experiments were carried out to ascertain whether or not a larva taken from its mine would bore into a healthy leaf; the results were negative in every case, the larvae either pupating or, more frequently, dying.

The eggs remain permanently on the scab, and this gives an easy method of estimating the number of larvae involved in producing a blotch. The empty egg-shell, if examined microscopically, is seen to contain the excreta of the larva's first feed on the leaf tissue.

That part of the leaf where the larva is still feeding is greenish yellow, and if held to the light is transparent enough to reveal the larva at work. Two days suffice

for the epidermis to turn brown. The size and shape of the mines vary indefinitely, being controlled solely by the number of larvae present. No signs of cannibalistic habits amongst the larvae have been noticed, but the larval mortality is great, large numbers of blotches, on being opened, having been found to contain the shrivelled remains of larvae at all stages of growth. Larvae of Chalcidoid parasites very frequently are seen attached to the body of the leaf-miner, and the blotches may contain these parasites in all stages except the imago. This subject will be dealt with more fully under the heading "Natural Enemies."

The larvae continue to mine the leaves for periods varying between 3½-5 weeks, when a semicircular slit is made by the caterpillar in the upper surface of the blotch. The larva crawls to the edge of the leaf and drops by a silk thread to a leaf lower down, where it seeks the lower surface for pupation. The cocoon is most often found under a leaf that has not been mined by larvae; in very few cases (less than one per cent.) were cocoons found on the upper surface of coffee leaves collected in the field.

The construction of the silken cocoon already described occupies about a day. Then the larva rests one day, the pupa being found invariably two days after the emergence of the larva from its mine.

The pupal stage was found to occupy from 7-10 days at Kabete. This was estimated from large numbers of full-grown larvae collected in plantations and allowed to pass the pupal period in captivity. Field observations were made as a check.

After the moth has emerged, its empty pupal skin may be seen projecting from one end of the silken web.

TABLE II.
Comparison of the Life-cycle in various Countries.

Country.	Observer.	Year.	Duration of stages in days.			Complete Life-cycle in days.
			Egg.	Larva.	Pupa.	
Antilles ..	Guérin-Méneville (1) ..	1842	7-8	15-22	6	28-36
Cuba ..	Cook (18) ..	1905	4-5	21	3-7	28-33
Mexico ..	Tellez (19) ..	1906	—	7-20	6	—
Porto Rico ..	van Zwaluwenberg (31)	1917	3-8	7-15	3-9	13-32
" ..	Pierce (32) ..	1917	4-6	21	3-7	28-34
" ..	van Zwaluwenberg (28)	1915	—	11-13	6-8	—
Uganda ..	Gowdey (30) ..	1917	5	12-16	8	25-29
Kenya ..	Box ..	1922	7-12	24-35	7-10	38-57

Natural Enemies.

The following Hymenopterous parasites of *Leucoptera coffeella* have been recorded in literature :—

BRACONIDAE :

- Apanteles bordagei*, Giard Réunion.
Exothecus letifer, Mann Brazil.

EULOPHIDAE :

- Zagrammosoma multilineatum*, Ashmead Porto Rico.
Chrysocharis livida, Ashmead Porto Rico.
Eulophus borbonicus, Giard Réunion.
Eulophus cerniostomatis, Mann Brazil.

During the experiments conducted at Kabete, three species of Hymenopterous parasites have been reared from the leaf-miner. Specimens of two of these species were submitted to Dr. J. Waterston, who has determined one of them as a Braconid of a genus allied to *Hormius*, and the other as a Eulophid, *Atoposoma variegatum*, Masi, var. *afra*, Silvestri.*

The writer has reason to believe that the third species is also an Eulophid of the genus *Chrysocharis*. The Braconid is undoubtedly scarce in the Kabete area, and its value as a controlling agent need not be discussed. Two specimens were bred from pupae of *L. coffeella*, and although many hundreds of empty cocoons of the leaf-miner were examined, this Braconid was found to infest less than 0.1 per cent. of the pupae during the season of investigation.

The two Chalcids are undoubtedly of value, especially the *Atoposoma*, which was often to be found in its larval state attached to the leaf-miner caterpillar. At certain seasons it was indeed difficult to find any blotch that did not contain two or three empty pupa-cases of this parasite, particularly so at the close of a rather severe drought in February 1922. Many blotches contained as many as 6 or 7 living pupae of this parasite. The imago leaves the blotch by eating a minute circular hole in the upper epidermis, and by counting these exit-holes an estimate was formed of the number of blotches that had contained the *Atoposoma*. From December until the middle of January the percentage was about 25, during February 45 to 50, and then a gradual decrease until the present time (May), when it is difficult to find the *Atoposoma*.

Both the Eulophid parasites occurred in all plantations inspected by the writer in the Kyambu and Nairobi coffee areas, but the unnamed species is not so well distributed, being often localised to one or two acres in a large plantation.

Samples of coffee leaves infested with the leaf-miner were brought back from a plantation in the Solai Valley (6,000 feet), Nakuru district, on the occasion of a visit by the writer in December 1921, and a study of the material showed that 65 per cent. of the blotches were or had been inhabited by *Atoposoma*. The other Eulophid was not found in this sample.

The writer believes in discouraging efforts to destroy all blotched leaves by burning, as has been recommended. The leaves should of course be picked at the season when the larvae of the moth are most abundant, and the parasites as they emerge should be allowed to escape.

A predatory enemy of the leaf-miner is a small green spider, which makes nests on the lower surface of coffee leaves, and in the webs of which the adults of *L. coffeella* have been found in large numbers.

Economic Status.

Leucoptera coffeella, in all papers dealing with it in countries other than East Africa, is recorded as the most serious of the insect pests of coffee. Cook (18) states that it causes a loss of from 20-40 per cent. of the foliage of coffee grown in Porto Rico, and 56½ per cent. loss in Cuba. It was stated by Mann (8) that the coffee crop of Brazil loses one-fifth annually through the agency of the white leaf-miner.

In East Africa, records from Tanganyika Territory, Uganda, and Kenya seem to point to the fact that it is only a minor pest, but occurs wherever coffee is grown. It has, however, been known to cause a loss of about 25 per cent. of one crop in the Nakuru district, but the owner of that plantation is inclined to the opinion that such an occurrence was exceptional, and still believes that the leaf-miner is of little significance from the farmer's point of view.

* Silvestri, A.—Boll. Lab. Zool. Portici, ix, 12th December 1914, p. 218, fig. xii; there recorded as the parasite of a moth, *Oecophyllembius neglectus*, Silv., the larva of which mines the leaves of olives.

The writer has found that the "Mocha" variety of *Coffea arabica*, which is the principal kind grown in Kenya, is more readily attacked than "Blue Mountain" coffee when the two varieties grow in proximity, but the latter is quite severely attacked when no "Mocha" plants are in the vicinity. No plant other than coffee is known to be attacked by *L. coffeella*.

An attempt was made to estimate the number of "blotched" leaves present on coffee grown near Kabete. On 10th December 1921 ten shoots were collected at random, without preference, and an examination of these showed that of 89 leaves, 53 were damaged by the leaf-miner, and that on the 53 leaves were no less than 86 distinct blotches. A summary of all stages of the insect found on the ten shoots is as follows:—

Number of eggs	..	..	..	..	..	..	143
" " larvae	..	..	..	..	..	..	69
" " pupae (living)	..	..	..	..	..	..	26
" " empty cocoons	..	..	..	..	..	..	21

Obviously, with such a small number of shoots no really reliable estimate could be made; nevertheless, on that occasion, it would be safe to state that 40 per cent. of the leaves of the plantations visited were affected.

When a leaf has been badly mined it soon falls to the ground, and cases of almost complete defoliation have been known to occur at certain seasons. Generally, however, each tree may be found to have about 10 per cent. of its leaves blotched, and the continual destruction of leaf surface will tend to cause the trees to lose health and in time render them very weak.

Another danger lies in the fact that the coffee thrips, *Diarthrothrips coffeae*, Williams (see this Bulletin, vi, p. 269, 1915) seeks shelter in the mines of *Leucoptera* during rainy weather. It was found that blotched coffee leaves collected during the rains contained the adult thrips, and these were found under the "scab" of a blotch from which the leaf-miner had emerged. Of course, the thrips would shelter in any crevice or irregularity in the leaf or stem, but it would not be incorrect to state that to allow the leaf-miner full sway in a plantation is deliberately to encourage thrips.

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A SYSTEMATIC MONOGRAPH OF THE TACHARDIINAE OR LAC INSECTS
(COCCIDAE).

By JOSEPH CONRAD CHAMBERLIN,
Stanford University, California.

(PLATES X-XX.)

CONTENTS.

	PAGE
INTRODUCTORY :—	
Acknowledgments	148
Previous Systematic Work	148
Scope of Present Paper	148
Geographical Distribution	149
Ecology	149
Economic Importance	149
Habit	151
COMPARATIVE MORPHOLOGY :—	
Form of Adult Female	151
Mouth Parts	152
Antennae	152
Brachia and Brachial Plates	152
Spiracles and Canellae	153
Legs	154
Dorsal Spine and Dorsal Spine Ducts	154
Perivaginal Pore Clusters	155
Marginal Duct Clusters	155
Ventral Duct Clusters	157
Dorsal and Miscellaneous Duct Clusters	157
Anal Tubercle	157
Anal Fringe	158
Anal Ring and Anal Ring Setae	158
Anus and Anal Tube	158
Internal Pygidial Apodemes	158
Immature Stages and Males	159
General Explanations	159
SYSTEMATIC TREATMENT :—	
Subfamily TACHARDIINAE	161
Tribe TACHARDIINI	163
Supergeneric group of <i>Tachardiella</i>	164
Genus <i>Tachardia</i>	164
Subgenus <i>Tachardia</i>	165
Subgenus <i>Metatachardia</i>	172
Genus <i>Tachardiella</i>	173
Subgenus <i>Tachardiella</i>	174
Subgenus <i>Austrotachardiella</i>	187
Supergeneric group of <i>Austrotachardia</i>	194
Genus <i>Austrotachardia</i>	194
Tribe TACHARDININI	199
Genus <i>Tachardina</i>	199
Subgenus <i>Afrotachardina</i>	201
Subgenus <i>Tachardina</i>	204

INTRODUCTORY.

Acknowledgments.

At the suggestion of Professor G. F. Ferris, of the Department of Entomology of Stanford University, I have undertaken the following review of this extremely important, equally interesting, and almost equally neglected group of the COCCIDAE. My acknowledgments are due to Professor Ferris for his aid in the preparation of the paper and of the material upon which it is based. To my fellow-students, Mr. Bryan Duncan, Mr. Carl Duncan, Mr. W. H. Irwin and Mr. P. N. Annand, I desire to extend my thanks for their aid in testing the included keys.

The material upon which the paper is based has been obtained from a number of sources, and the author's thanks are due to all those who have most liberally loaned or contributed specimens. I am especially indebted to Mr. E. E. Green, who, with the utmost of liberality, has made available all the species contained in his collection. Professor T. D. A. Cockerell has contributed type material of several of the species described by him and representatives of other species as well. Other species have come from the collection of Mr. O. E. Bremner, which is deposited in the Stanford Collection of Coccidae. A number of species in the Stanford Collection were collected by Professor Ferris in the south-western United States and in Lower California. The source of all material will be acknowledged under the various species.

All the specimens listed under the heading "Material Examined" are deposited in the Stanford Collection of Coccidae unless otherwise noted. Holotypes of all new species have been selected and are deposited in the same collection.

Previous Systematic Work.

The previous systematic work on this group has consisted for the most part of the description of individual species, and there exists no adequate general discussion of the subfamily as a whole. Green, in the fifth part of his "Coccidae of Ceylon," gives the best general discussion that is at present extant, but it is limited to the species occurring in Ceylon. MacGillivray, in his recent book, "The Coccidae," gives a notably inadequate and misleading account of the group, which is evidently based upon *T. lacca* with some mention of characters that occur in certain American species of the genus *Tachardiella*. Apart from these, there is nothing that even purports to deal with the group as a whole.

In 1901 Cockerell, in describing *Tachardina albida*, divided the old genus *Tachardia* into three subgenera and gave rather inadequate diagnoses of them. From then on no attention was paid to this matter until 1921, when MacGillivray raised them all to generic rank without giving any very good reasons for so doing. Except for these rather abortive efforts, there has never been an attempt to place the classification on a really sound basis. These facts will explain to a great extent the necessity for the rather pronounced changes adopted in this paper.

Scope of the Present Paper.

In the preparation of this paper 44 species have been examined, these including several that are here described as new. In addition to these, there are six valid species that I have not been able to see. One of these is well enough described to include in the keys and phylogenetic chart, and this leaves but five the status of which is doubtful. Of these all but one can be positively assigned to their proper genus and subgenus. From this it may be seen that the present work can fairly lay claim to being truly monographic in scope. All the species that have been examined have been redescribed and figured, even though some of them have been well described by other authors. I estimate, however, that certainly not more than half, and probably not more than a third, of the actual number of species in this subfamily are known at present.

The scope of this work is easily stated. Habits, lac characteristics, the males, the immature stages and comparative measurements are but briefly considered. The work is based almost entirely upon the morphological characters of the adult females with a view to reducing the systematic study of the group to a morphological basis. All positive observations are mentioned in the generic or specific descriptions, and any character not mentioned may be regarded as not having been observed. It is the author's belief that the system of classification arrived at by this method is entirely justified and is, as a matter of fact, conservative, and in this opinion he is supported by Professor Ferris.

Geographical Distribution.

The geographical range of the subfamily, as indicated by the records of specimens, as well as the probable actual range, is indicated on the accompanying map (text-fig. 1). Species have been recorded from all the continents but Europe. In North and South America they have been taken in the south-western United States, Mexico, the island of Jamaica in the West Indies, British Guiana, Brazil and Argentina. In Australia they have been recorded from several widely separated localities. In Asia they are recorded from Formosa, Burma, the Philippine Islands, India and Nepal, and in the islands between Asia and Australia they are recorded from Ceylon and Java. In Africa they have been taken in the Union of South Africa and in Uganda.

It is evident from these records that the actual range of the subfamily is much greater. In all probability it is continuous from southern North America to southern South America, over all of Australia, the intervening islands between Australia and Asia, all southern Asia, and probably all Africa south of the Sahara.

Ecology.

In general it may be said that the species of this group are tropical or sub-tropical, apparently reaching their greatest abundance in regions of limited rainfall. They occur on a great variety of hosts, usually on the twigs and smaller branches or occasionally on the larger limbs or even the leaves. Parasites are evidently numerous, and in most cases where anything definite is known concerning them it is given under the species or a reference is given as to where the information may be found. As may be inferred from this account, actual knowledge as to their ecology is extremely limited.

Economic Importance.

The resinous secretions of certain of the members of the genus *Tachardia* (as here limited) afford the very important commercial product known as lac or shellac, which forms the basis of sealing wax and various varnishes, and is used extensively as an insulating material in electrical work. The lac of *Tachardiella fulgens*, under the name of "Jomilla," is used to some extent by the Mexicans medicinally and for repairing crockery, etc. *Tachardiella larreae* was at one time thought to have commercial importance, but this has now been definitely disproved, at least so far as the "wild lac" is concerned. Various other species have been suggested as possible sources of lac, but it is only within the genus *Tachardia* that it has so far been found possible to recover it, although the species of all the genera except *Tachardina* secrete a true lac.

As pests these Coccids seem to be of little importance, but they have been reported on various trees of economic value from time to time and occasionally as in sufficient numbers to be harmful. At any rate all such species are at least a potential source of economic danger as well as value. Among the species mentioned as being on plants of economic value are *Tachardina theae*, *Tachardina aurantiaca*, *Austrotachardia angulata*, *Austrotachardiella cydoniae* and *Austrotachardiella gemmifera*.

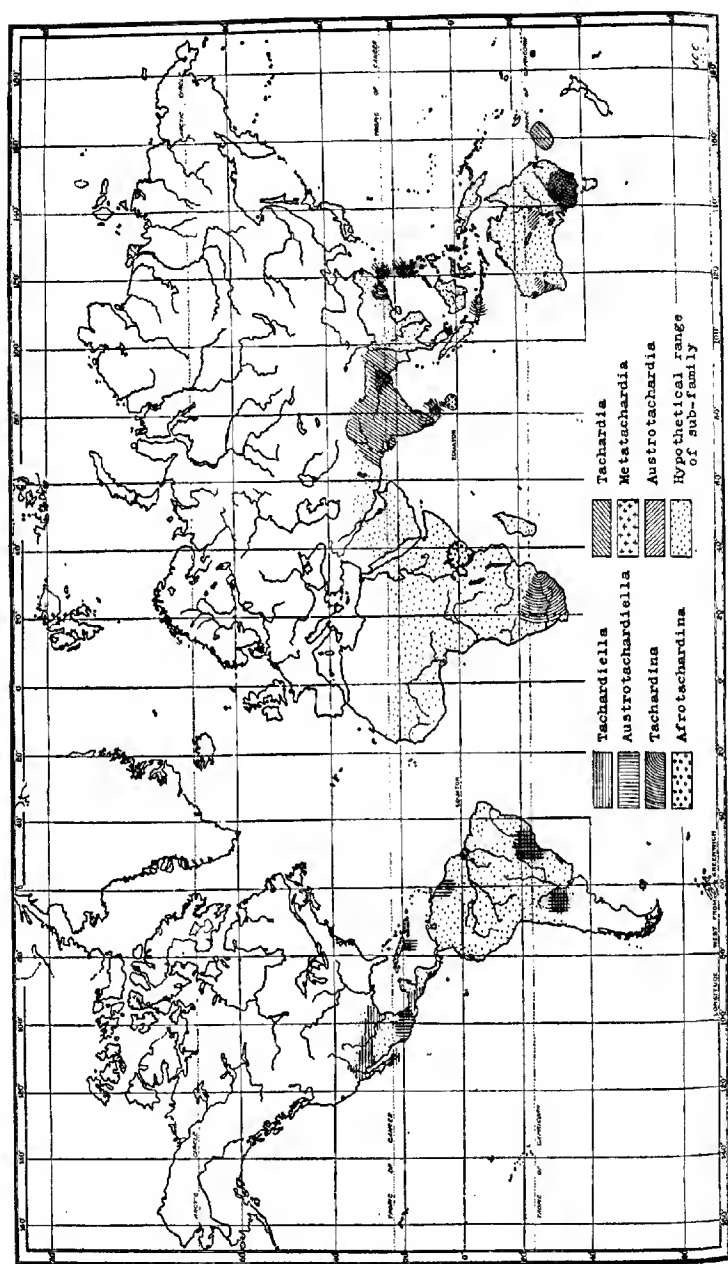


Fig. 1. Geographical distribution of the TACHARDIINAE.

Habit.

In regard to the habit of the insects, I can do no better than quote from the description given by Green in the fifth part of his "Coccidae of Ceylon."

"The resinous cells—or tests—when isolated, conform approximately to the shape of the contained insects, but may be sculptured or diversely moulded externally (e.g., *conchiferata*, *minuta*, *decorella*). The cavity of each cell communicates with the surface by three small apertures, two of which are associated with the stigmatic processes, the third being in apposition with the caudal extension of the anal orifice. During the life of the insect these apertures are occupied by tufts of delicate white filaments emanating from ceriferous pores on the organs concerned. The deposition of lac commences during the larval stages and is continued—increasing in thickness—with the development of the insect throughout the nymphal and adult stages.

"As the insects while still quite small are closely imprisoned within a rigid case of resin, it is evident that their growth must be accompanied by a corresponding augmentation of the internal dimensions of the cell. The final size of the adult female is many times greater than that of the nymph or the early adult female, necessitating a great increase in the size of the cavity. It is a little difficult to understand how this is effected. The probable explanation is that the resinous secretion, though apparently a solid substance, is in reality a viscous fluid which would respond to slow pressure exerted by the growth of the contained insect. We know that a very small amount of heat will make a stick of sealing wax (which is derived from lac) sufficiently plastic to bend by its own weight or to adapt itself to the shape of any surface upon which it may be resting. Possibly the heat of the tropical sun comes to the assistance of the imprisoned insect by inducing the necessary plasticity of its resinous envelope.

"The male puparium is similarly constructed, but is usually of a more or less slipper-shaped form, with the posterior aperture proportionately larger, and closed by a dense resinous operculum."

I cannot entirely concur in the above account as to the probable method of growth of the cells, at least in the genus *Tachardina*, for it is difficult to imagine the horny and extremely refractory test of the species of that genus responding enough to the heat of the sun to allow of increase in size of the contained insect. As an alternative hypothesis I would suggest the possibility of a secretion which is poured out by glands and which so softens the lac as to permit growth. Possibly the unusual glands connected with the dorsal spine are in some way associated with this. Although this spine does not appear until the final moult, this fact does not entirely destroy such a theory, for until this moult the insects are quite small, and the greater part of their growth takes place later.

In view of the conclusions concerning the wide separation of *Tachardina* from the rest of the subfamily, derived from a purely morphological study, it is interesting to note the confirmation offered by the nature of the secretion in the two large groups. Thus it has been shown as a result of chemical analysis that the lac secreted by the genus *Tachardiella* is almost identical in composition to that of *Tachardia*. And while an analysis has never been made of the lac of *Austrotachardia*, in all respects it seems to behave as a true lac. However, the case is very different when we come to *Tachardina*, for here the tests are of an extremely hard and refractory substance, which more nearly resembles gutta-percha in its consistency than the lac secreted by the other three genera mentioned above.

COMPARATIVE MORPHOLOGY (Plate x).**Form of the Adult Female.**

The general form of the species of this group varies from that of the almost smoothly globular *Tachardia meridionalis*, through the pyriform *Tachardia lacca*,

to the various remarkably lobed species of *Tachardiella*. It is probable that the form is quite definite for each species, but much of the distinctive shape is lost in slide preparations, and no attempt has been made to deal with this character in the present paper.

Mouth Parts.

The mouth parts present no unusual structures except that in some species they are associated with a pair of small lobes, called the post-oral lobes, which are situated just behind the mouth. Green (Coccidae of Ceylon, Part V, p. 403) has expressed the opinion that these lobes may represent vestiges of the anterior legs, but they seem too intimately connected with the mouth parts for this, and, furthermore, in some species, where the undeniable vestiges of legs are present, they are clearly recognisable as such in spite of their great reduction.

I have personally observed these lobes only in the genus *Tachardia*, as here restricted, where the position of the mouth parts at the very apex of the body is such as to reveal their presence easily.

Antennae.

The antennae, while always present, vary considerably and generically. In *Tachardina*, *Tachardiella* and *Metatarchardia*, where they reach their greatest development, they are fairly long and may consist of as many as 5-7 segments (Plates xvi, j; xx, v). In some cases the segmentation has apparently been lost, but the antennae remain as long as in the species where segmentation appears. In *Tachardia* and *Austrotachardia* they are much smaller (Plate xiii, l) and are less conspicuous. In *Austrotachardia* they appear at times to consist of a single segment. In all cases they are tipped by from two to seven setae, the number and size occasionally being of systematic value. Taken as a whole, the antennae are of little specific importance.

Brachia and Brachial Plates.

The brachial plates, or, as they have been called by previous authors, the stigmatic plates, form one of the most characteristic features of the subfamily. They are not only peculiar to this subfamily, but they vary to such an extent as to be of great value in both generic and specific determinations. Instead of the customary designation as stigmatic plates, I am using the term "brachial plates," for the association with the spiracles is not always obvious, and the use of the first term affords no convenient way of designating the arms upon which the plates are usually borne.

These plates are evidently fundamentally associated with the anterior spiracles, and their function is to secrete the filamentous waxy threads that keep the spiracular openings of the test from being closed by the secretions that cover the body. Essentially the plates are composed of a heavily chitinated area, which is perforated by pores of various types (Plates xii, xv, xix, xx). As a rule the plates are borne upon a more or less elongate and chitinous, or sometimes membranous, process, here spoken of as a "brachium," but in some cases they are sessile, as in *Tachardia fici* and *T. meridionalis*. Curiously enough, it is in the same genus that the brachia reach their greatest development, as in *T. lacca* and *T. conchiferata*. In the other genera they are typically well developed.

In *Tachardia* it is usual for the anterior spiracles and the corresponding brachia to be united, forming, really, a single continuous structure (Plate xii, A). This is particularly well shown in *T. fici* and *T. albizziae*. In *T. fici*, in which the brachial plates are almost sessile, the brachia are probably represented by the broad chitinous collar that surrounds the plate itself (Plate xii, H). In such cases, however, I am using the term brachial plate to include the whole structure.

The brachial plates themselves assume many different forms. In *Tachardina* they are almost flat (Plate xx, r) and only rarely have a shallow depression (Plate xx, 1). In *Austrotachardia* they are invaginated to form a deep "crater," which is often bordered by a peculiar fringe consisting of alternate setae and acute chitinous lobes (Plate xix, c). In *Tachardiella* they are usually oval and shallowly depressed (Plate xv, b), while in *Tachardia* they are subcircular with a shallow depression, which in turn bears smaller depressions or "dimples" (Plate xii, r).

In all cases I refer to the primary depression of the plate as the "crater." The crater is perforated by more or less numerous pores and ducts, from which issue the white waxy filaments that keep the spiracular openings in the test from becoming clogged. The portion of the plate surrounding the crater is the collar or crater rim. The secondary depressions of the crater in *Tachardia* are the dimples (Plate xii, F₁), and these are a very characteristic feature of this genus. The nearest approach to dimples that is found in any other genus is in *Tachardiella*, where in *T. ingae* we find the crater irregularly secondarily depressed (Plate xv, A). These depressions differ fundamentally from the true dimples of *Tachardia*, since they lack the large central or nuclear duct that is found in the latter genus. This nuclear duct is strongly specialised, being much larger and longer than the others. A diagrammatic cross-section of one of these dimples is shown in Plate xii, F₁, which will give an idea of their form and structure in *Tachardia lacca*, in which they are especially well developed.

There are two fundamentally different types of pores or ducts that are found on the brachial plates. The first, which is found generally throughout all the genera but *Tachardina* (with one interesting exception), seems to be more or less of the order of the ordinary type of tubular ducts or simply perforations through the chitin in other cases. The other type, which is almost confined to the genus *Tachardina*, is in the nature of a tubular perforation, with usually five or six converging spinose processes arising around its rim, much as shown in Plate xx, d. Thus, taken from a perspective angle they appear as spines or setae, while as seen from a terminal aspect they look like pores with five or six loculi. From their peculiar structure and deceitful appearance they are termed in this paper pseudospines. In the case of one species, *T. albida*, apparently all but one of these converging processes is lost, and hence it is extremely difficult to differentiate between them and true setae. A figure of this interesting type, so far as it could be worked out, is shown in Plate xx, s. In one species of *Tachardina* they are apparently replaced by true setae (*T. affluens*).

An interesting and perhaps significant exception to the rule that the pseudospines are confined to *Tachardina* is their presence in the crater of *Tachardiella lycii*, an American species.

To sum up, it may be said that *Tachardina* is characterised by flat or only slightly depressed brachial plates beset with pseudospines; *Austrotachardia*, by extremely deep craters bordered by a spinose fringe; *Tachardiella*, by oval, shallowly depressed craters without true dimples; *Tachardia*, by shallow craters with dimples.

Spiracles and Canellae.

The two pairs of thoracic spiracles alone are present, and the anterior pair is always larger than the posterior. Normally the anterior pair occupies the position found in other species of Coccids, but in the subgenus *Tachardia* and in two species of *Tachardina* the order is reversed, and the morphologically posterior pair of spiracles are actually anterior to the morphologically anterior pair (Plate x, d). Green says in regard to this: "The spiracles during the development of the adult insect so completely alter their normal positions that the two pairs can no longer be described as anterior and posterior." Nevertheless, in the present paper the morphologically correct terms are used regardless of the actual position of the spiracles.

In structure the spiracles consist essentially of a strong, variously, usually roughly oblong, shaped chitinous base specialised to support the masses of tracheae that they supply. They are usually, if not always, furnished with ceriferous pores in greater or less abundance. These pores are of two types. Those of *Tachardina* are characterised by a projecting central process or rod, which is surrounded by five loculi (text-fig. 6, F, G, H), while in all the other genera the central rod is apparently lacking (Plate xviii, Q).

In complexity and size the anterior spiracles differ greatly in the various species. As a rule, those of *Tachardia* and *Tachardiella* exceed in complexity (number of bordering pores and size) those of *Tachardina* and *Austrotachardia*.

The posterior spiracles are very uniform throughout, in all cases being small (Plate xviii, F, G, K) and usually associated with a few quinquelocular pores, which are of the same type as those of the anterior pair.

Associated with the anterior spiracles in some species of all the genera, except *Tachardia*, is a more or less distinct band or line of pores, which extends ventrad from each spiracle toward the mouth. For this line of pores I am using the term canella, which has been proposed by MacGillivray, although he has entirely misinterpreted the position of these structures in the TACHARDIINAE. In *Tachardiella* and *Austrotachardia* the canellae often extend to a point just a little caudad of the mouth parts, and in two cases in *Tachardiella* they approach rather closely the posterior spiracles (Plate xviii, X, P). In *Tachardina* they are much less developed and usually consist of an area of pores that is often no larger than the spiracle itself (text-fig. 6, K, N). The pores of the canellae are of the same quinquelocular types as those of the spiracles. In the descriptions they are spoken of as star pores.

Legs.

I have observed the presence of legs in most of the species of *Tachardiella* that I have examined, and in one species of *Tachardia* and one of *Austrotachardia*. Brain records their presence in one species of *Tachardina*. In all cases they are merely minute chitinous points or protuberances (Plate xviii, U, S) usually without traces of segmentation. They may usually be found by reference to the spiracles, the posterior pair being just caudad of the posterior spiracles and the median pair just cephalad of these spiracles. The anterior pair are more difficult to locate, but may be found in some species on either side of the mouth parts and usually just a little caudad of the modified maxillae.

Dorsal Spine and Dorsal Spine Ducts.

The dorsal spine is one of the most characteristic and curious features of the subfamily. It occurs on the dorsal aspect cephalad of the anal tubercle and is known to be present in all but one of the known species (see under *Tachardina albida*, Ckll., p. 206). In size and shape the organ varies considerably, but essentially consists of a large, conical, hollow spine with an elongate slit or pore at the apex (Plate xvi, H, I). Through this orifice a remarkable system of ducts reaches the surface. These ducts are of a chitinous nature; they are usually preserved in an ordinary mount and are occasionally of decided systematic value. This value may be found to be even greater than I realise upon a more careful study of them than I have been able to make.

In the genus *Tachardia* particularly, and to a less extent in *Tachardiella*, the spine tends to be borne upon a more or less elongate, slender, fleshy protuberance or pedicel, which is often rather prominent (Plate xii, G), as, for example, in *Tachardia lacca* and *T. (Metatachardia) conchiferata*.

There are two general types of ducts found in connection with this spine, which I have here termed *dendritic* and *non-dendritic* respectively. The dendritic type is characteristic of all the genera excepting *Austrotachardia*, and varies considerably

in details (Plates xii, G, K, M; xvi, E, F; xx, N, Q), but agrees in being to some extent dendritically branched with little chitinous nodes at the tips of the branches. The non-dendritic type, found only in the genus *Austrotachardia*, is unbranched (except within the spine itself) and is terminated by a small node or enlargement (Plate xix, L, M). The dendritic type usually, if not always, enters the base of the spine as a single duct, while in the non-dendritic type there is, so far as is at present known, no case where the ducts within the spine itself are less than three or four.

The dorsal spine of *T. (M.) conchiferata* is notable from the fact that within the long slender supporting pedicel and enclosing the debouching ducts is a chitinous envelope or sheath extending as far inward as the length of the spine itself (Plate xii, M). This sheath will in all probability be found to be present in most, if not all, of the other species in a membranous condition. Its chitinisation then and not its presence is the anomalous feature.

In all cases the length of the spine is taken to mean the distance from its apex to where it attaches to the slender supporting pedicel.

Perivaginal Pore Clusters.

In the genera *Tachardia* and *Tachardiella* there are to be found about the vaginal opening a series of from four to many clusters of circular pores, which are individually characterised by the presence of from 5-12 or even more loculi (Plates xiv, A₁; xvi, A₁, Q). The presence of four such clusters is characteristic of *Tachardiella* (Plates x, A; xvi, A), while from 18-50 is the number found in *Tachardia* (Plates x, D; xiv, A). No traces of perivaginal pores are to be found in either *Tachardina* or *Austrotachardia*, although, as I hope to show in the following systematic treatment, this is not at all an indication of genetic affiliation between these genera.

Marginal Duct Clusters.

The marginal clusters of ducts may be divided into two general types based upon the fundamental character of the ducts composing them. The first type, characteristic of the genera *Tachardia*, *Tachardiella* and *Austrotachardia*, is composed of ducts of the general type shown in Plate xvii, F₁. These ducts consist essentially of a rather elongate chitinous tube, which when seen from a terminal aspect shows a median subcircular area, surrounded by a narrow rim or collar, the latter bearing usually a small loculus at one point (Plate xvii, v). From this loculus arises a filamentous prolongation of the duct. In some cases this filamentous prolongation has a subglobular enlargement just after leaving the distal portion of the duct (Plate xiii, i). This is more characteristic of the ventral ducts, however. As to whether these ducts particularly terminate in the peculiar nodes or spermatozoid-like tips was not determined. The second type, found only in *Tachardina*, is typically much shorter than the usual "tubular" type of ducts and varies fundamentally in the shape of the terminal central loculus, which ordinarily presents the appearance shown in text-fig. 8, E₃. It is difficult to express this shape in words, but it may be likened to an elongate letter O with a lateral lobe on either side. In some cases this central loculus is reduced to a mere irregular slit, as in the subgenus *Afrotachardina*, but in such a case there are always present other "accessory ducts," which show the typical structure (text-fig. 8, A). In addition to the central loculus there is usually a marginal loculus placed as in the ordinary tubular duct, but occasionally, as is typically the case in *Afrotachardina*, there may be as many as 6, and 2 or 3 is the ordinary number (text-fig. 8, A). This prime division in the subfamily as expressed by the character of the ducts is to my mind based upon as fundamental a character as appears in the group.

In addition to these two general divisions there are three other divisions that may be made on the basis of the number of clusters actually present. Thus in *Tachardina* there are 14-16 circular or ovate clusters arranged in pairs (Plate x, B), two pairs usually preceding the anterior spiracles. In *Austrotachardia* there are five pairs of clusters present and usually an anterior median cluster (Plate x, C), while in *Tachardia* and *Tachardiella* there are three primary clusters (Plate x, A, D), one of which precedes the anterior spiracles. In one subgenus, *Austrotachardiella*, there is a group of species that have these primary clusters divided into two distinct subclusters, so that it appears as if there were six rather than the three typical primary clusters. *Austrotachardiella bodkini* illustrates beautifully these clusters in the exact process, so to speak, of subdivision (Plate x, A).

It is possible definitely to homologise the marginal clusters of *Austrotachardia* with those of *Tachardia* and *Tachardiella* very easily by the assumption that its original three clusters have all been definitely subdivided into two, exactly as we have seen taking place in *Austrotachardiella*. The anterior median cluster would then simply represent the secondary fusion of the anterior pair of "subclusters." This point may be easily seen upon comparison of Plate x, A and C.

It is scarcely more difficult to homologise the larger number of clusters found in *Tachardina* with the postulated three-paired condition. By a hypothetical bisection of the primitive anterior cluster and a trisection of each of the other two, we have the facts in the case very easily satisfied and by a process which we know is entirely usual in the group.

On still another basis than the two given above there are three type divisions of the marginal clusters possible. These types may be designated the *simplex*, *duplex* and *triplex* types respectively. In any case this division is secondary to either of the two preceding ones. The simplex type consists of ducts of a single size and type of structure only, and is found best expressed in *Tachardia lacca* (Plate xiii, F). The duplex type consists essentially of ducts of two types or sizes. The more I have investigated the more I find the apparently simplex clusters disappearing and their place taken by duplex types. Thus in *Tachardiella*, in which I had at first thought were many simplex types, I have found that most, if not all, are in reality of an obscure duplex type, the secondary or duplex ducts being very small depressions with long attached thread-like ducts that terminate in rather elaborate spermatozoid-like heads (Plate xvii, B, E). There is a considerable number of duplex types. In one, typified by *Tachardia greeni*, both the central or *nuclear ducts* and the secondary or *duplex ducts* are of the same structure and differ essentially only in size. Another type is that above described, where the duplex ducts are of the spermatozoid type before mentioned. Another duplex type is found in *Austrotachardia*, where the duplex ducts are very slender tubular ducts, scarcely larger than the filamentous prolongation that leaves them (Plate xix, J, K). A more unusual type is found in *Tachardina*, where the nuclear and duplex ducts are present in almost equal numbers (*T. iernata*, text-fig. 8, H). In many species of *Tachardina* there is a tendency toward a duplex type, but the differentiation is destroyed by the ducts that intergrade between the two extremes, for example, in *T. lobata* (text-fig. 8, L).

The triplex type is confined to *Austrotachardiella* and consists of a well-developed duplex cluster of the spermatozoid duct type, which has, surrounding the duplex ducts, a more or less distinct band of a third type of duct, usually a short tubular type (text-fig. 5, A, B, E, G, I).

The spermatozoid ducts mentioned as being a characteristic duplex type vary considerably as to the shape of their internal termination, as may be seen by comparing the various figures given (Plates xiii, J; xvii, A₁, E, O, V₂; xix, O; and text-fig. 5, D). There is some evidence, which I have not been able to follow out, that seems to show that these ducts may be generally distributed over the body and are not necessarily confined to the vicinity of the marginal ducts.

Ventral Duct Clusters.

In most, if not all, species there is within (ventrad of) the marginal clusters another system of localised duct groups, which typically number three pairs but occasionally more, as, for example, the five typical pairs in *Austrotachardia*. Usually they are less prominent than the marginal clusters, but occasionally this is reversed, as in *Austrotachardia angulata* (Plate x, c), where they are considerably larger than the marginals. In *Tachardina* they reach their minimum so far as conspicuousness is concerned, and here they are extremely difficult to make out. In *Tachardiella* they are typically well developed (Plate x, A). They have reached their greatest modification in the subgenus *Tachardia*, where, as a consequence of the peculiar distortion characteristic of this genus, they are typically found at the extreme anterior tip of the body as an irregular dorsal cluster (Plate x, D). In all cases, even in *Tachardina*, they appear to consist of small true tubular ducts, which are variously modified in shape and vary considerably in the way by which the filamentous prolongation leaves the main body of the duct. Perhaps more characteristic of them than of the marginal ducts is the globular swelling of the filamentous prolongation (Plate xvii, I₄, T₅).

Dorsal and Miscellaneous Duct Clusters.

In some species of *Tachardiella* there is found a loose cluster of perhaps 8-12 large tubular ducts (Plates x, A ; xvii, F), to which I apply the term *dorsal ducts*. They are especially prominent in *T. cornuta*. They are situated on the dorsal side, almost directly over the area included between the mouth parts and the posterior spiracles.

In addition to this type of dorsal cluster, there is another type, which, to my knowledge, is found in but two species, *Austrotachardia angulata* and *Tachardiella gemmifera*. The cluster consists of a more or less distinct band of ducts, which form a fairly large circle surrounding the area immediately dorsad of the mouth parts (Plate x, c). The cluster is more prominent in *angulata*, and the ducts seem to be larger. I have no suggestions regarding this peculiar occurrence, except that the ducts may possibly be demonstrated in other species with the aid of better preparations. *Tachardina* apparently is typically possessed of a small group of minute dorsal ducts, as in *T. lobata* (Plate x, B).

There are a number of small ducts found near the mouth parts in *Austrotachardia* and some species of *Tachardina*. These are discussed under the species concerned, not being of sufficiently general occurrence to discuss here.

Anal Tubercle.

The anal tubercle is the more or less heavily chitinated posterior prolongation of the body, which bears the pre-anal plate (in some groups), the supra-anal plate, the anal fringe and the anal ring with its complement of setae, pores and ducts. The chitinous portion of the tubercle consists principally of the supra-anal plate (and the pre-anal plate when present), which extends over the dorsum, around the pleurae and part of the sternum, but rarely, if ever, forms a complete tube. Nevertheless, it may be regarded as an almost complete collar surrounding the tip of the tubercle and extending for a greater or less distance cephalad (Plates x ; xiv, A to C ; xix, A, c ; and text-figs. 3, 7).

The pre-anal plate is characteristic of the genus *Tachardiella* and the subgenus *Metatachardia*, and is also present in two species of *Austrotachardia*. Typically it is larger than the supra-anal plate and nearly always smooth and rather weakly chitinated. As a rule it is invariably longer than broad (compare figures).

The supra-anal plate may be smooth, variously tuberculate or even hispid. Ventrally the anal tubercle usually bears a few setae between the approximate ends

of the supra-anal plate (Plate xiv, A, B). In the genus *Tachardina* the anal tubercle as seen in profile rises very steeply from the fringe base (text-fig. 8, A, C); as a rule it is rather rugosely granulate, as is the case in *Austrotachardiella*.

Anal Fringe.

The anal fringe is of considerable importance in considering the major divisions of the subfamily and of some of the genera, but is of only slight specific importance. Throughout the group it is of the same general type, consisting essentially of a medially cleft, posteriorly projecting chitinous process or apron, which is joined to the supra-anal plate. Besides the median cleft, which is almost invariably present, the fringe is variously lobed or cleft and is often provided with setae, which are interspersed among the lobes or processes.

In general there are a long and a short type of anal fringe. In the long type (Plate xvi, B, and text-fig. 7, D) the lobes project for a considerable distance posteriorly and usually terminate just a little short of the tips of the anal ring setae. In the short type (Plates xvi, D; xix, A, C), on the other hand, the anal ring setae extend far beyond the tips of the fringe. It almost appears as if in the long type there is a retraction of the anal ring rather than an elongation of the fringe. However, this is not the case, as may easily be seen by a comparison of the relative lengths of the two types. Besides these large groups each genus and subgenus that is here considered is characterised by definite types of lobing, which are fully described and discussed under the generic and subgeneric heads. In *Tachardina*, which is normally a long-fringed group, there is found one species, *Tachardina longisetosa*, possessed of a remarkably reduced fringe, which apparently lacks even the median cleft. This is fully described and discussed under the species. The only other long-fringed group is the subgenus *Austrotachardiella* of the genus *Tachardiella*.

Anal Ring and Anal Ring Setae.

Throughout the subfamily, with a few exceptions, not only in the adults but in both larval stages as well, the anal ring seems to be typically divided into four distinct sectors (Plates xi, J; xviii, L). In the genus *Tachardia* the anal ring is apparently always six-lobed. The other type is where the sectors are entirely fused to form a continuous ring. This latter condition is typical of the subgenus *Afrotachardina* and the *decorella* group of *Tachardina*. It also appears in the larval stages of some of the species of *Tachardiella*, e.g., *T. larreae* (Plate xi, I). In all cases the ring bears ten long setae, which in the case of the quadrately-sectored species are borne as follows: three setae in each of the dorsal sectors and two in each of the ventrals. In the six-sectored type the two ventral and dorsal sectors each bear two setae and the latero-median sectors bear a single one each. In *Tachardina* (*Afrotachardina*) *longisetosa* the continuous anal ring appears superficially ten-sectored, owing to an emargination between each two setae.

Anus and Anal Tube.

The anus opens through the anal ring. There is often, if not typically, a small chitinous process, which extends a little caudad of the surface of the anal ring and which may be considered as a trough-like extension of the chitinous tube that lines the anal ring and sometimes extends a short distance into the anal tubercle.

Internal Pygidial Apodemes.

In two species of *Tachardina*, *T. ternata* and *T. actinella*, there occurs a remarkable pair of more or less heavily chitinised rods or processes that extend from the base of the supra-anal plate to a position caudad of the dorsal spine (text-fig. 6, A, B). There is nothing similar to them found anywhere else in the subfamily, except in the

subgenus *Austrotachardiella*, where in most species there may be found immediately anterior to the supra-anal plate a pair of subcircular or horse-shoe shaped chitinous structures or apodemes (Plate xvi, c). Their function cannot even be guessed at, but they are probably thickenings of the body wall. They are more fully discussed in the systematic portion.

Immature Stages and Males.

Such information as there is concerning the immature stages and the males is incorporated in the following systematic diagnosis of the subfamily.

General Explanations.

As an aid in identifying and visualising the various morphological characters and terms used in the preceding discussion and in the following systematic treatment, a chart of the four principal generic types is given in Plate x. Practically every character used in this work is pictured and named in this diagram.

In *Tachardia* and *Tachardiella* use has been made of a very diagrammatic figure of the anal tubercles, simply to show the general size and shape of the supra-anal plate and the pre-anal plates. Owing to preparation methods, these parts are nearly always considerably distorted, and due allowance must be made in comparing actual specimens with these diagrams.

The only morphological measurement given is that of length and is that of slide-mounted specimens.

Since it is obvious that species are not of equal rank, assuming the truth of evolution, the use of the phylogenetic chart (text-fig. 2) is adopted as the best means of really giving the author's concept of their comparative rank. In other words the diagram furnishes a "sliding scale" of taxonomic rank without bringing into play an excessive use of polynomials. Subspecies, although none is here recognised, are considered in the light of geographic forms, *i.e.*, in exactly the same way accepted by ornithologists and mammalogists. *Forma*, a term in general use among workers on the Hydroids, Echinoderms and similar groups, is used in the same sense in which they use the term. It will include forms that have coincident geographical range but differ more or less constantly in some small or intergrading characters. Minor morphological differences that scarcely or doubtfully form sufficient basis for their separation as species could likewise be used as a basis for their separation as forms.

Thus a forma might differ in small but heritable characters from the typical form, or, in a variable or polymorphic species, might be no more than a fairly constant type due to its habitat or something similar ("vegetative differences"). A forma is of less rank than a subspecies. For example, a species might be divided into several formae and no subspecies, or it might be divided into a number of subspecies, each of which might contain numerous formae. Naturally, in view of the fact that a forma might later be raised to specific or subspecific rank, it must be subject to the same rules of nomenclature as species or subspecies. I here wish to express my thanks to Dr. W. K. Fisher, of The Hopkins Marine Station of Stanford University, for his suggestion concerning the term forma and its definition. Some more or less interesting speculations concerning the origin and dispersal of the various genera are given in the systematic section under the "Remarks" on the different genera.

The phylogenetic chart (text-fig. 2) gives my final conclusions concerning the relationships of the species and groups. The reasons for my conclusions as to relationships are presented in the preceding morphological discussion and in the following pages of the systematic treatment, and must be gleaned from my diagnoses and the "Remarks" found under the group, generic and specific headings.

In conclusion it might be well to state a few of the more interesting future problems to be found in and solved for this group. A comparative study of the ducts, both from a gross and histological standpoint; a comparative study of the secretions, both histologically and chemically; breeding and transference experiments with a view to determining variability and host tolerance; more careful comparative studies of certain morphological characters, such as the mouth parts, the anal tubercle, and especially the form of the living insect when divested of its test. These form a few of the more important lines of investigation which may be followed with great profit.

SYSTEMATIC TREATMENT.

Family COCCIDAE.

Subfamily *Tachardiinae*.

1901—Cockerell, *The Entom.* xxxiv, 249.

1903—Fernald, *Catalogue of the Coccidae.* 123.

1921—MacGillivray, *The Coccidae.* 148.

1922—Green, *The Coccidae of Ceylon.* Part v, 402.

Adult Female.—With vestigial antennae; with a pair of brachial plates, which are usually borne on processes or brachia, the whole more or less associated with the anterior spiracles; with thoracic spiracles only, the posterior pair small or almost vestigial; with legs absent or at most represented by small protuberances or chitinous points; typically with a conspicuous dorsal spine cephalad of the anal tubercle; with the anal opening borne at the apex of a tubercle, which consists typically of a supra-anal plate bearing posteriorly a chitinous fringe that is medially deeply cleft; with a distinct anal ring, which bears ten setae.

Always enclosed in a secretory test, which assumes various forms but is always convex and frequently lobed and variously sculptured. The secretion may be a true lac, as in *Tachardia* and *Tachardiella*, and to a less extent in *Austrotachardia*, or it may be a hard and horny secretion, as in *Tachardina*. The test is perforated by three dorsal openings, one over each of the brachial plates and one over the anal opening. In living material there may always be found delicate, white, waxy threads, which are secreted by the numerous ceriferous ducts or pores on the brachial plates and anal ring, issuing from these apertures.

Second Stage of Female.—With the mouth parts and antennae (Plate xi, JJ) as in the adult; brachia lacking; brachial plates always present, but differing from those of the adult in that the crater is much shallower and the pores are usually more scattered (Plates xi, C, D, E; xv, M), in *Tachardia*, however, the dimples are already beginning to differentiate (Plate xi, E, K); with spiracles much as in adult, but with difference in size between the two pairs not so marked (Plate xi, V, V'); canellae represented (in those species in which they are present in the adult) only by a few star pores; legs absent or present entirely as in adults; with dorsal spine absent or (as in *Tachardiella texana*) represented only by a small, round-based, lightly chitinated hump (Plate xi, CC); with no perivaginal pores; marginal ducts present, but usually not definitely grouped into clusters; there are exceptions to this, however, as in *Tachardia* sp. from Formosa (see discussion under that heading, p. 173), where they are not only differentiated and apparently show traces of true duplex ducts, but are likewise subdivided, as in the adults of some species of *Austrotachardiella* (Plate xi, W); ventral ducts apparently present or absent, in no case prominent; pre-anal and supra-anal plates much as in adults, but less extreme in their differentiation; anal fringe of at least the same type as in adult (Plate xi, H); anal ring differentiated as in adults (Plate xi, I, J).

It is believed that most second stage larvae, if not all, will fall within the generic characterisations given for the adults, making allowance, of course, for characters not yet developed in the second stage forms. In general shape the insects in this stage are more or less broadly lanceolate, not being differentiated into the shapes characteristic of the adults.

First Stage Larva.—With the antennae six-segmented and of the same general type as illustrated in Plate xi, A; brachia absent; brachial plates represented by a small chitinous, usually depressed, area laterad of each anterior spiracle, this plate bearing a small number of pores (of the star type?), with several, usually 2-3, bordering setae (Plate xi, L, M, N, P, Q, R, S, T, X, Y, II), which are usually, but apparently not always, slender in *Tachardia* and *Tachardiella* (Plate xi, N, Y), or thick and stout, as is usually the case in *Austrotachardia* and *Tachardina* (Plate xi, Q, X); thoracic spiracles alone present, the anterior pair but little, if any, larger than the posterior pair, always with a few (2-3) star pores (Plate xi, II); legs of the typical larval Coccid form; with no trace of dorsal spine or perivaginal pores; marginal ducts present but not arranged in clusters, there being but 4-5 ducts along either side; supra-anal plate showing a distinct median cleft (Plate xi, F, B), the fringe continuous with the plate and consisting in some cases of four short ligulate lobes (Plate xi, B) or variously modified (for example, as in Plate xi, F); anal fringe always of the short type; with a long "tactile" seta on either side of the supra-anal plate, often longer than entire body of insect (Plate xi, G); immediately anterior to these tactile setae appear a pair of more or less stout spines or pseudo-cerarii (Plate xi, F), which differ considerably from species to species (Plate xi, B, F, Z, AA, DD, EE, FF, GG, HH); with anal ring either continuous (Plate xi, I), four-sectored (Plate xi, J) or six-sectored (Green, 1922, Plate clxxii, fig. 5); anal ring always bearing six long, stout, setae; in the four-sectored type each dorsal sector bears two setae and each ventral sector a single one each, in the six-sectored type each sector bears a single seta. Apparently the distribution of these three types of anal ring parallels, to an undetermined extent, that of the same types in the adults.

The above conclusions are based upon a rather superficial survey and may require revision in certain details.

All the larvae conform very closely to the type above described and show very plainly the homogeneity of the subfamily as a whole. However, I believe it entirely possible to distinguish most of the groups and some of the more distinct species by characters found in the larvae, although it must unquestionably be on the basis of small differences. The characters which would most probably be of generic value are perhaps the brachia and supra-anal plate. Good specific characters are to be found in the brachial plates as well as in the proportions of the antennae, etc.

I have made no observations as to whether the large divisions based upon the character of the ducts holds through the first stage or second stage larvae. This would be a very interesting point to establish.

Adult Male.—I have myself made no observations on the males and simply quote the following statement from Green, 1922:—

"The adult male may be either apterous or alate, both forms usually occurring in the same species. The antennae are normally ten-jointed, the terminal joint tapering to a point and bearing one or more knobbed hairs at its apex. In the apterous form the number of antennal joints is often reduced to nine. The head carries four prominent black ocelli. The penial sheath is long and slender and acutely pointed. The posterior extremity of the body carries a pair of long, white, waxy filaments."

General Remarks.—The system of classification adopted in this paper is almost entirely original. The only attempt to break up the old genus *Tachardia* was by Cockerell, in 1901, when he named two new subgenera *Tachardiella* and *Tachardina*, defining them strictly upon a basis of habit, geographical distribution, and the lack

of a dorsal spine in *Tachardina albida*, the type of that subgenus. These characters were impossible to use and are, indeed, of no importance, and his subgenera were disregarded until MacGillivray in 1921 raised them to generic rank, still using habit and lac characteristics as the critical features.

Green, 1922, makes the following statement regarding the use of the name *Tachardia*. "The genus as originally erected by Signoret in 1874 was called *Carteria*; but that name, having been preoccupied by Diesing in 1865 for a genus of Protozoa, is now superseded by *Tachardia*, as designated by Blanchard in 1886."

Systematic Position of Subfamily.

But little can be said in regard to the position or derivation of the TACHARDIINAE. The following statement, which was written by Prof. Ferris at the author's request, is believed to express, as well as is possible at the present time, the position held by this subfamily. As suggested by Ferris, the TACHARDIINAE are believed by the author to represent a family of the superfamily Coccidoidea, although this elevation of rank is not made here. Ferris's statement is as follows:—

"The COCCIDAE that have previously been included in the genus *Tachardia* constitute a very peculiar and isolated group. They are provided with structures that are seen in none of the other COCCIDAE and that are apparently not homologous with anything found in any other representatives of the family. There is no very clear evidence as to what their relationship with the remainder of the COCCIDAE may be. Even the first larval stage, which is frequently very enlightening, is here of no especial help. Neither do the ducts and pores furnish anything more than the most general suggestions. About all that can be said at present is that the relationships of the group are *not* with the Monophleboid forms (*Icerya*, *Xylococcus*, *Orthesia*, etc.), nor with the Diaspidines, and probably not with the COCCINAE (= LECANIINAE).

"Their position then is certainly that of a group equivalent in rank to any of the other groups of the COCCIDAE, whatever that rank may be. Personally, I regard them as a family, the TACHARDIIDAE, in the superfamily Coccidoidea."

The genera may be separated by means of the following key:—

1. With distinct perivaginal pore clusters in the adult female 2
Without perivaginal pore clusters 3
2. With four subequal perivaginal pore clusters; anal fringe of more or less
ligulate lobes *Tachardiella*, Ckll. p. 173
With more than four perivaginal pore clusters, usually with 18-50; anal fringe
of sharply acute lobes *Tachardia*, Blanch. p. 164
3. Brachial plates always with a very deeply invaginated crater; the crater rim
fringe-like *Austrotachardia*, n. p. 194
Brachial plates usually flat, occasionally with a shallow crater; in all cases
with a broad, collar-like rim surrounding the pore-bearing area
Tachardina, Ckll. p. 199

The supergeneric groupings are defined and discussed in their appropriate places.

Tachardiini, tribus n.

(Long duct group.)

This large group is characterised by the invariable possession of elongate, true tubular ducts of the type illustrated in Plates xiii, B₁, B₂, xvii, A₃, G₃, G₄, G₅, F₁, xix, J₂, K₂, and text-fig. 5, G; by cancellar pores without the median spine (Plate xviii, o); by the almost entire absence of pseudospines on the brachial plates (see remarks under *Tachardiella lycii*), and by never having the marginal clusters divided into more than six pairs at the most—usually there are three pairs.

This group, which includes all the TACHARDIINAE, excepting only *Tachardina*, is almost surely of subfamily rank, assuming that the TACHARDIINAE are truly of family rank.

Suprageneric Group of Tachardiella.

(Shallow crater group.)

Characterised by the invariable presence of perivaginal pore clusters in adult females; by comparatively shallow craters and by dorsal spine ducts of a much branched, dendritic type (Plates xii, G; xvi, 1); by marginal clusters primitively of three pairs of undivided duct groups, in some forms, notably *Austrotachardiella*, these being bisected so that there appear to be six pairs, never with apparently five or five and a half pairs, as is the case in subgroup 2.

This group includes the two closely related genera, *Tachardia* and *Tachardiella*.

Tachardia, Blanchard.

(Plates x, D; xi (part); xii; xiii; xiv; and text-figs. 1, 2.)

1874—*Carteria*, Signoret, Ann. Soc. Ent. Fr. (5), iv, 101.

1882—*Carteria*, Comstock, Rep. U.S. Dep. Agr., 1881-82. 209.

1891—*Carteria*, Maskell, Trans. N.Z. Inst. xxiv, 54.

1886—*Tachardia*, Blanchard, Zoologie Médicale. 1.

1897—*Tachardia*, Maskell, Trans. N.Z. Inst. xxix, 330.

1901—*Tachardia*, Cockerell, The Entom. xxxiv, 249.

1903—*Tachardia*, Fernald, Cat. Coccidae. 123.

1920—*Tachardia*, Brain, = *Tachardina*.

1921—*Tachardia*, MacGillivray, The Coccidae. 148-149.

1922—*Tachardia*, Green, Coccidae of Ceylon. Part v, 402.

Haplotype.—*Tachardia lacca*, Kerr; India, Burma, Nepal, etc.

Diagnosis.—Crater shallow and dimpled; perivaginal pore clusters always present and always more than four in number, usually 16-50; three pairs of marginal clusters always present; anal fringe of short type, of acute lobes and setae.

Morphology.—Antennae either of long or short type, segmentation usually obscure; brachia long and heavily chitinised or reduced to mere mound-like protuberances; brachial plate shallowly depressed into a more or less circular crater, which in turn is subdepressed into from 4-12 bowl-like hollows or dimples, each of which is possessed of a central, enlarged tubular nuclear duct; anterior spiracles rather conspicuous and always closely associated with the brachia or, in their absence, with the brachial plates, with which they are often firmly fused; canellae apparently never present; posterior spiracles small and tending to be borne upon a smoothly ovate chitinous patch or shield, as is also often the case with the anterior spiracles; position of spiracles often reversed, so that the true anterior spiracles are dorsad and actually posterior to the morphologically posterior pair; legs observed in a single species as small chitinous points; dorsal spine always present, often with basal spinous processes and often variously bent and deformed, usually if not always borne upon a fleshy protuberance or tubercle, which is often as long as the spine itself; perivaginal pore clusters always present and variable in number, but always more than four, usually 16-50, non-uniform in shape and size; three pairs of marginal duct clusters always present, varying from elongate, gently curved or serpentine lines or rows of ducts to small ovate chitinous patches containing 8-10 ducts; ventral duct clusters present in all species, but varying greatly in their distribution and nature; anal tubercle well developed, supra-anal plate short or long and only rarely preceded by a pre-anal plate; anal fringe short, consisting of numerous sharply acute lobes which seem to alternate with apparently true setae; anal ring setae projecting far beyond short anal fringe; anal ring six-segmented.

Remarks.—There is no question that this genus is most closely related to the American *Tachardiella*, with which it agrees in many important respects, such as the presence of perivaginal pore clusters, typically three pairs of marginal and ventral duct clusters, and in the general resemblances between other characters, such as the dorsal spine and its ducts. As a pure hypothesis based upon careful consideration of their comparative morphology and geographical distribution, I should suggest that *Tachardia* is a derivative of a more primitive *Tachardiella*-like form, or forms, originally inhabiting America, which gave rise to both these genera. On this basis it would seem that its point of entry into Asia was north through Alaska and thence south, through Japan and China, to its present range. This migration then would have taken place during one of the numerous warm epochs of preceding geological periods. See remarks under *Tachardia* (*M.*) *conchiferata* and *Tachardia* sp. in the following pages.

The genus is divided into two well-defined subgenera, which may be separated by means of the following key:—

- Brachia very heavily chitinised, with a distinct terminal constriction behind crater rim; anterior spiracles distinctly anterior to posterior spiracles . . . *Metatachardia*, n.
- Brachia never with such a constriction; spiracles reversed so that the anterior spiracle is nearly always located at least a little posterior to the posterior spiracles (in some cases they may be almost in line) . . . *Tachardia*, Blanchard.

***Tachardia*, Blanchard, subgenus typicus.**

Haplotype.—*Tachardia lacca*, Kerr; India.

Diagnosis.—*Antennae of short type; spiracles at least perceptibly reversed; pre-anal plate absent.*

Remarks.—Differences between the subgenera, other than those given in the diagnosis, are to be found in the dorsal spine, this subgenus not possessing the peculiar internal chitinous sheath surrounding the ducts that is present in *Metatachardia*. However, this difference may simply be due to the fact that the sheath in this subgenus is entirely membranous. There are apparently no essential differences between the anal fringes of the two groups.

Tachardia is still further separable into three smaller groups, which are discussed under their appropriate headings. The species of the subgenus can be separated by means of the following key:—

1. Supra-anal plate (anal tubercle) large and elongate, being always a little longer than greatest width 2
- Supra-anal plate more abbreviated, being always a little broader than greatest length 3
2. Brachial plates borne upon distinct and elongate brachia . . . *lacca*, Kerr. p. 170
- Brachial plates sessile, with no traces of brachia . . . *ebrachiata*, sp. n. p. 170
3. Brachial crater subcircular or subquadrate; not at all longer than broad . . . 4
- Brachial crater subrectangular in outline; distinctly longer than broad . . . *albizziae*, Green. p. 166
4. Brachial plate and supra-anal plate subequal *fici*, Green. p. 168
- Brachial plate distinctly smaller than supra-anal plate (one-third smaller) . . . 5
5. Brachia distinctly visible; supra-anal plate with $1\frac{1}{2}$ times the area of brachial plate *greeni*, sp. n. p. 168
- Brachia entirely absent; supra-anal plate with twice or more the area of brachial plate *meridionalis*, sp. n. p. 167

Group of *T. albizziae*.

Remarks.—Includes only the single species, *T. albizziae*, and is characterised by the peculiar type of marginal duct cluster, which consists of an ovate chitinous area

with a comparatively small number of nuclear ducts. It is further distinguished by the extremely close fusion of the brachial plate with the anterior spiracle. It is most closely related to the *T. fici* group, with which it agrees as regards the broad supra-anal plate.

Tachardia albizziae, Green (Plates xii, A, C, L; XIII, I, R; xiv, F, J).

1903—*Tachardia albizziae*, Green, Ind. Mus. Notes. v, 98.

1911—*Tachardia albizziae*, Green, Journ. Econ. Biol. vi, pt. 2, 32-35, Plate ii, fig. 24-33.

1922—*Tachardia albizziae*, Green, Coccidae of Ceylon. v, 411-414, Plate clxxii.

Type Host and Locality.—*Landolphia* sp.; Ceylon.

Previous Records.—Green (1922) gives the following records. Ceylon: Peradeniya, Watagama, Kelani Valley, Tangalla and Anarodhapura, on the smaller branches of *Albizzia stipitata*, *Filicium decipiens*, *Harpullia cupanoides*, *Nephelium litchi*, *Amherstia nobilis*, *Hemicyclia sepiaria*, *Schleichera trijuga*, *Croton lacciferum*, *Theobroma cacao*, *Ficus nervosa* and *Landolphia* sp. India: Darjceling, on *Croton caudatum*.

Material Examined.—Ceylon, on *Filicium decipiens*, *Albizzia stipitata*, *Harpullia cupanoides*, *Ficus nervosa* and *Amherstia nobilis*. Ceylon: Kelani Valley, on *Albizzia stipitata*; Kelawewa, on *Hemicyclia* sp.; Hambantota, on *Schleichera trijuga*; and Peradeniya, on *Landolphia* sp. All material received from Green.

Habit.—From Green, 1922: "Resinous tests of adult female bright castaneous when fresh, darkening with age, but usually so covered with a sooty fungus as to appear black. An isolated test is subglobose, flattened beneath where it adheres to the stem of the plant. . . . The surface may be smooth or granulorugose. . . . Diameter of test 2.5-3.5 mm."

"The resin of this species is the principal material employed in the local (Ceylonese) lac industry. It is known to the Matale lac-workers as 'Keppitiya laccada,' and to those of Tangalla as 'Kon laccada.'"

Morphology.—Antennae very small, apparently two-segmented, and tipped by three setae (Plate xiii, R); brachia short, appearing as small, rounded, chitinated protuberances always immovably fused with and part of large anterior spiracle and brachial plate (Plate xii, A); brachial plate with 4-5 dimples, which are rather weakly defined (Plate xii, C); posterior spiracles only slightly anterior to anterior spiracles; dorsal spine typical, as long as width of brachial plate (Plate xii, L); perivaginal pore clusters number about 18, rather small and altogether typical; marginal duct clusters apparently displaced, as in *lacca*, but to a less extreme extent, consisting of 10-15 nuclear ducts surrounded by an ovate, characteristically reticulated area (Plate xiii, I); ventral duct clusters apparently as in *lacca* (Plate x, D), consisting of 22 or 23 small ducts; supra-anal plate (Plate xiv, F) entirely smooth; anal fringe typical (Plate xiv, J); anal ring six-sectored. Length 2-4 mm.

Remarks.—This peculiar species occupies a rather isolated position and is closely related to no species known to me.

In regard to a peculiar colour variation found in this species, I quote the following from Green, 1922:—

"The adult female is normally a uniform rich crimson colour, but there is a variety that is a bright gamboge yellow colour in all stages. . . . As noted above, there are two distinct varieties of the insect, one crimson, the other yellow. They are distinct in all stages, the crimson adult producing crimson larvae, and yellow adults yellow larvae. I have not observed any yellow males. Nor have I seen any intermediate forms. The two colours may be confined to separate colonies, or they may be mingled together. In a block of three cells one of the insects was red, the other two yellow. A pure yellow colony was observed upon

Harpullia cupanioides, but both yellow and red forms were freely intermingled upon a plant of *Nephelium litchi*. The red form is by far the more common, and is the only form that has been observed upon *Albizia*."

In all respects this peculiar colour variety appears to behave like a Mendelian recessive mutant.

The following statement is likewise from Green, 1922: "The colonies are attacked by larvae of a moth (*Eublemma amabilis*) and also by several TINEINAE. Chalcid parasites bred from this species have been named by Ashmead *Tachardiaephagus thoracicus*, and a Braconid (which is probably parasitic upon the larva of the *Eublemma*) has been called *Bracon greeni*, Ashmead." Green describes the male and larvae in "Coccidae of Ceylon," Part v.

Group of *T. fici*.

Remarks.—This group includes three rather closely related species, which are characterised by having the supra-anal plate broader than long, and by the tendency toward chitinisation around the marginal ducts. The group as a whole is rather closely related to the *T. lacca* group, although one species, *T. meridionalis*, has certain characteristics reminiscent of *T. albizziae*.

***Tachardia meridionalis*, sp. n.** (Plates xi, m; xii, d, j; xiii, e, m, p; xiv, l).

Type Host and Locality.—On unknown host from "Australia."

Material Examined.—One lot of material from the Bremner Collection of Coccidae, without a host citation and listed as from "Australia." Barring the possibility of erroneous labelling, it will probably be found to be native in Victoria or New South Wales. From Ehrhorn: apparently part of the same material mentioned above.

Habit.—Tests roundish, almost globular, slightly roughened exteriorly. Lac itself scanty, walls of test somewhat thin and clear light reddish in colour. Diameter 3 mm., height 2 mm.

Morphology.—Antennae very small and with few traces of segmentation, tipped by two long and two short setae (Plate xiii, m); brachial plate sessile, the brachia being represented by no more than a slight mound-like swelling; brachial plate similar to that of *fici*, but somewhat smaller (Plate xii, d), being only half as large as supra-anal plate, with 5-6 distinct dimples, the crater distinctly subangular in outline; anterior spiracle much as in *fici*; posterior spiracles typical and always distinctly preceding anterior spiracles; dorsal spine slightly shorter than width of brachial plate (Plate xii, j); perivaginal pore clusters 35 or 36 in number, many of them grouped more or less closely together to form somewhat larger clusters; marginal clusters situated as in *lacca*, but with the distortion carried to a less extreme extent, each consisting of a smoothly and acutely convoluted band of pores situated upon a slightly chitinised oval plate (Plate xiii, e), suggesting, in some measure, the type of cluster found in *albizziae*; ventral duct clusters present in a three-paired condition, anterior ventrals consisting of 50-60 small loosely scattered ducts, median ventrals of 8-9 scattered ducts, posterior ventrals similar to median; a small compact group of star pores present as in *greeni*, on either side of the mouth parts (Plate xiii, p); supra-anal plate typical, twice as large as brachial plate; anal fringe typical (Plate xiv, l); anal ring six-segmented. Length 3 mm.

Remarks.—There is little doubt that this species is most closely related to *T. greeni*, sp. n., in spite of some considerable differences. In some ways this form is almost an intermediate between the normal spiracled and reversed spiracled groups of the genus *Tachardia*, as is witnessed by the normally differentiated ventral duct clusters and the less extensive distortion of the position of the marginal duct clusters. It is possible that the interesting mouth parts clusters of star pores present in this species and *greeni* represent vestiges of canellae, a fact that would lend weight to the theory that this genus is a derivative of the American *Tachardiella*.

Owing to the lack of data, it is with some reluctance that this species is named, but since there is an abundance of good material and since it occupies a rather interesting position in the group and is sufficiently distinct, it has been thought best to name it.

Tachardia greeni, sp. n. (Plates xii, I, K; xiii, B, L; xiv, A, G, I).

1920—*Tachardia fici*, Green, Morrison, Philipp. Journ. Sci. xvii, 178. Fig. 20, a-f. (Misidentification.)

Type Host and Locality.—Los Baños, Philippine Islands, on *Ficus ulmifolia*.

Previous Records.—Recorded by Morrison as *Tachardia fici*, Green, from the aerial roots of a banyan tree at Manila.

Material Examined.—One lot of the type material received direct from H. E. Woodworth, Professor of Entomology at the College of Agriculture at Los Baños, P.I. Collected 20th January 1922.

Habit.—Unknown to me.

Morphology.—Antennae very small, segmentation lost, tipped by three setae (Plate xiii, L); brachia short and but weakly attached to the anterior spiracle, which resembles that of *fici* but without a distinct "outer" chitinous outline as in that species and possibly with more pores; brachial plate small, crater not definitely outlined, with about four distinct dimples; posterior spiracles as in *lacca*; spiracles more distinctly reversed than in *meridionalis* and *fici*; dorsal spine typical in shape, as long as width of brachial plate, the duct much less branched than in *meridionalis* and *fici* (Plate xii, K); perivaginal pore clusters about 58, non-uniform in size (Plate xiv, A), an individual perivaginal pore is shown in Plate xiv, A₁; marginal duct clusters arranged as in *lacca*, individual clusters distinctly of a duplex type, the cluster as a whole forming a much convoluted and prominent band of ducts, which tend to be borne upon areas of heavier chitination (Plate xiii, B), nuclear ducts 9-11, secondary or duplex 100-120; ventral ducts as in *lacca*, consisting of 25-40 small scattered ducts (cluster on either side of mouth parts); mouth parts cluster of star pores present as in *meridionalis*; supra-anal plate typical of group (Plate xiv, A, G), only slightly hispidous at tip; anal fringe more or less typical, but with lobes distinctly smaller and less numerous than in *fici* or *meridionalis* (Plate xiv, I). Length 2 mm.

Remarks.—This species is apparently most closely related to *meridionalis*, as is witnessed by the similarities in the brachia and brachial plates, the mouth parts cluster, etc., but nevertheless is well distinguished from any other species in the genus by certain well-defined characters, such as the great prominence and peculiar duplex type of marginal duct clusters. In the extreme to which the reversal of the spiracles has been carried, it suggests rather strongly the *lacca* group.

Tachardia fici, Green (Plates xi, E; xii, H; xiii, C, D, N, O, T; xiv, B, D, K).

1903—*Tachardia fici*, Green, Ind. Mus. Notes. v, 97-99, Plate xix, fig. 4.

Type Host and Locality.—Monghyr, India, on *Ficus bengalensis*.

Previous Records.—Monghyr, India, on *Ficus bengalensis* and *Ficus religiosa*.

Material Examined.—Part of type material and a series of specimens from Coimbatore, India, on *Butea frondosa*. All material received from Green.

Habit.—(After Green.) On the small terminal branches of its host; test sub-globular; often with supplementary globules attached to the surface; bright fulvous or castaneous in colour. Often massed together on twigs, but even then the shape of the individual tests may be distinguished.

Morphology.—Antennae, although small, better developed than in any other species of the subgenus, apparently 3-4 segmented and tipped by four setae (Plate xiii, N); brachia usually if not always very short, rarely appearing as abbreviated

tubular processes, but more usually as small rounded protuberances; brachial plates large, of much the same type found in *lacca*, but comparatively more developed (Plate xii, n), usually with 6-7 dimples, rarely with as few as three or four; anterior spiracles large and rather closely attached to brachia (Plate xiii, t); posterior spiracles as in *lacca*; spiracles reversed, but never so greatly as in *lacca* or *greeni*, occasionally the posterior spiracles will appear almost in a straight transverse line with anterior spiracles; dorsal spine typical, half as long as diameter of brachial plate, with rather marked spinosities and spurs basally, the ducts not so complexly branched as in *lacca* and more so than in *greeni*; perivaginal pore clusters 16-18; the clusters, while not uniform in size, more or less smoothly round in shape; marginal duct clusters somewhat similar in shape and size to those of *greeni*, but distinctly less conspicuous and of a simplex type consisting of from 40-50 ducts (Plate xiii, c, d); no star pore clusters near mouth parts, as in *meridionalis* and *greeni*; ventral duct clusters present in positions more or less opposite their respective marginal clusters, loosely clustered and ill-defined (Plate xiii, o); anal tubercle typical of group, supra-anal plate more hispid than in *meridionalis* or *greeni* (Plate xiv, b, d); anal fringe typical (Plate xiv, k). Length 2-3 mm.

Remarks.—It is rather difficult to decide as to the affinities of this species, suggesting as it does first one species and then another. However, taking everything into consideration, it seems to me that it is most closely related to the *greeni-meridionalis* branch of the *fici* group. Personally it seems to me that *fici* is not nearly as closely related to *lacca* as Green suggests, the character of the anal tubercle separating them quickly and easily. It must be admitted, however, that I may be wrong in assigning as much importance as I do to the supra-anal plate; in this case *fici* would without doubt occupy a place much closer to *lacca* than I have indicated in the above discussion and in the chart. The following is a quotation from one of Green's letters to Prof. Ferris: "I must warn you that *lacca* is a peculiarly polymorphic species. If you have seen the extreme forms only, you will be sure to regard them as distinct species. The principal variation is in the size of the stigmatic and caudal processes. They are affected by the depth of the resinous deposit. In weak colonies, where the incrustation is shallow, the processes remain short. But when the incrustation is very thick, the insect is drawn out and the processes become lengthened to enable them to reach the surface. I have found the most constant and reliable characters to be the form of the dorsal spine and the structure and arrangement of the ceriferous tracts surmounting the two stigmatic processes. My *T. ficus* (which, by the way, is preoccupied) is probably merely an extreme form of *lacca*." In view of the investigations I have made, I cannot agree that this variation is as great as Mr. Green states, and, consequently, I not only maintain *fici* as distinct, but name a new species for a form similar to *lacca* but without the brachia (*abrachata*, sp. n.). This is, however, a rather difficult group, and it is well to keep in mind the fact that further and more extensive investigations on the basis of more material may considerably modify my conclusions here given.

As to *fici* being preoccupied, I cannot concur. *Coccus ficus*, which is a synonym of *lacca*, if transferred to the genus *Tachardia*, would still retain the original spelling, becoming *T. ficus*, and hence, according to the international rules of nomenclature, would not preoccupy *T. ficus*, since the spelling differs essentially.

It is an interesting fact that one specimen examined had one brachial plate normal while the other was much reduced and contained only three dimples, although the normal number is 6-7.

Group of *T. lacca*, Kerr.

Remarks.—Includes two closely related species, *lacca* and *abrachata*, n. It is characterised principally by the elongate type of supra-anal plate, it always being distinctly longer than greatest breadth as contrasted with the broad plate of the *fici* group.

Tachardia obrachiata, sp. n. (Plates xi, F, G, T; xii, E, G; xiii, G, U, W).

Type Host and Locality.—"India," on "Manbhum."

Material Examined.—A single lot of material from Green, labelled "on Manbhum, India." Coll. J. H. Burkill.

Habit.—Similar to *lacca*, except that the lac is very much lighter in colour, being a clear reddish orange.

Morphology.—Antennae small but nevertheless almost twice as large as those of *lacca* (Plate xiii, w); brachia absent, in contra-distinction to those of *lacca*; brachial plate large as in *lacca*, crater distinct, with about eight dimples (Plate xii, E); collar subequal in width to diameter of crater; anterior spiracle large, subequal to brachial plate in size or even larger, same shape as in *lacca*; posterior spiracle similar to that of *lacca*; dorsal spine very similar to that of *lacca*, slender, two-thirds as long as width of brachial plate (Plate xii, G); perivaginal pore clusters similar to those of *lacca*, but not countable in available material; marginal duct clusters forming linear, sinuate rows of about 35 ducts each, very similar to those of *lacca* (Plate xiii, G), but with more of a tendency towards chitinisation of the duct areas; ventral ducts present as in *lacca*, but not so prominent; supra-anal plate same as in *lacca*; anal fringe typical and apparently closest to *lacca*. Length 4 mm.

Remarks.—As the above description will indicate, this species is closely related to *lacca*, and it would not be entirely surprising to find the two intergrading. Nevertheless, there appear to be several well-marked characters separating them, such as the particularly striking difference in lac colour and the sessile brachial plates, as well as other minor characters, so that it is the author's belief that the two should be maintained as distinct.

Tachardia lacca, Kerr (Plates x, D; xi, N; xii, F; xiii, F, K, S, V; xiv, C, H).

1782—*Coccus lacca*, Kerr, Philos. Trans. lxxi, 374.

1787—*Coccus ficus*, Fabricius, Mant. Ins. ii, 319.

1833—*Coccus lacca*, Ratzeburg, Mediz. Zool. ii, 226.

1874—*Carteria lacca*, Signoret, Ann. Soc. Ent. Fr. (5), iv, 102.

1896—*Tachardia lacca*, Green, Coccidae of Ceylon. Part i, 3.

1915—*Tachardia lacca*, Imms and Chatterjee, Ind. For. Mem., For. Zool. Ser. iii, no. 1, 42 pp., 8 plates.

1915—*Tachardia lacca*, Duport and Hautefeuille, Internat. Rev. Sci. & Pract. Ag. vii, no. 8. (Several abstracts published.)

1918—*Tachardia lacca*, Misra, Agric. Journ. Ind. xiii, no. 3, 405–415, plate and map.

1919—*Tachardia lacca*, Ramakrishna Ayyar, Journ. Bombay Nat. Hist. Soc. xxvi, no. 2, 621–628, 4 plates.

1919—*Tachardia lacca*, Ceylon Agr. Soc. Yearbook, 1919–20. 129.

1919—*Tachardia lacca*, Hassan, Quart. Journ. Mys. For. Assoc. No. 3, 197–24.

1919—*Tachardia lacca*, Fraymouth, Ind. Forester. xlv, no. 2, 74–79.

1921—*Tachardia lacca*, MacGillivray, The Coccidae. 148–149.

1922—*Tachardia lacca*, Green, Coccidae of Ceylon. Part v, chapter x, 408, Plate clxxi.

1922—*Tachardia lacca*, Hall, Min. Agr. Egypt, Tech. Sci. Serv. Bull. 22, p. 45.

References to this species, other than some of those listed above, may be found in the Fernald Catalogue and its supplements.

Type Host and Locality.—Unknown.

Previous Records.—India, Ceylon, Nepal, Burma. Listed in the Fernald Catalogue as from British Guiana, undoubtedly erroneously. Found on a great number of hosts. Green gives the following statement in 1922 regarding this point: "The list of plants upon which *T. lacca* occurs naturally, or upon which it has been cultivated

in India, is a long one, including 9 species of *Ficus*, 3 of *Dalbergia*, 3 of *Grewia*, 2 each of *Butea*, *Zizyphus*, *Albizzia*, *Acacia* and *Shorea*, and a single species of the genera *Schleichera*, *Eugenia*, *Xylia*, *Prosopis*, *Cajanus*, *Kejdia*, *Pithecolobium*, *Cassia*, *Dipterocarpus*, *Pentacune*, *Tamarindus*, *Garuga*, *Streblus*, *Caesalpinia*, but by far the more usual host plants appear to be (in the order named) *Butea frondosa*, *Zizyphus jujuba*, *Schleichera trijuga* and *Ficus religiosa*. Green states that the species is not indigenous to Ceylon. Hall, 1922, records an interesting, although rather unsatisfactory, attempt to introduce this species (?) into Egypt.

Material Examined.—"India," on unknown host (*Dr. G. Walt*); unknown host (*F. Moore*); India: Bangalore, on *Shorea talura*; Rajputana, on *Ficus elastica*; Raipur, on *Schleichera trijuga*. "Cuttack" (? India), on unknown host (*F. Moore*). Burma, unknown host (*F. Moore*). Ceylon, on *Nephelium litchi*; Peradeniya, on *Albizzia* sp. "from imported stock." All material received from Green.

Habit.—From Green, 1922: "Resinous tests of adult females closely agglomerated, forming an incrustation upon the branches varying in thickness from 4 to 7 mm. At an early stage of development, while the individuals are still isolated, the test of the female is of a symmetrical form with a double lateral series of rounded or bluntly pointed radiating processes, of which there are six pairs on each side. . . . A section of the incrustation reveals numerous pyriform or fusiform cells, which are adapted to the form of the mature insect."

Morphology.—Antennae minute, tipped by three setae (Plate xiii, x); brachia typically long, cylindrical and well chitinised, but if occasionally because of faulty preparation they appear somewhat shorter and rather weakly chitinised, at all events they are considerably longer than diameter of brachial plate; brachial plate not set off by a constriction, but sloping gradually and imperceptibly merging with the chitin of the brachium; brachial plate large, with 10-12 dimples (Plate xii, f); anterior spiracles large, distinctly greater in area than brachial plate (Plate xiii, v), borne upon a chitinous plate, which is fused with and forms part of the basal part of brachium; posterior spiracles small and borne upon a smoothly outlined, subovate chitinous plate (Plate xiii, s), which is situated immediately posterior to the mouth parts and far anterior to anterior spiracles; dorsal spine typical, half as long as width of brachial plate, ducts similar to, but somewhat more complex than, in *ebrachiata*; perivaginal pore clusters about 20, some fairly large and subovate; marginal duct clusters elongate convolute rows of about 25-30 tubular ducts (Plate xiii, f); ventral ducts near mouth parts in a scattered band or cluster; supra-anal plate smooth (Plate xiv, c); anal fringe typical (Plate xiv, h). Length 4-5 mm.

Remarks.—For remarks concerning the variability of this species, see comments under *T. fici* (p. 169). *T. lacca* is unquestionably very close to *ebrachiata*, but nevertheless the differences are sufficient easily to distinguish them, and it is the author's belief that there is no evidence to justify the conclusion that *ebrachiata* is but a phase of "polymorphic" *lacca*.

Green gives the following statement (1922) concerning the economic importance of this insect:—

"*Tachardia lacca* is the source of the commercial shellac so largely used in composition of varnishes, French polish, sealing wax, etc. A minor use in India is in the ornamentation of woodwork and in the manufacture of cheap bracelets and other fancy articles. It should be understood that 'lac work' has no connection with the 'lacquer' employed for somewhat similar purposes in China and Japan. The latter is compounded principally from vegetable gums.

"The body of the insect itself provides a crimson dye, which has now been largely replaced by aniline extracts. It gives its name to the pigment known as 'crimson lake.'"

There are a large number of treatises concerning the economic side of the lac industry, many of which are written strictly for the lac cultivators themselves.

Imms and Chatterjee, 1915, give a particularly excellent memoir upon this particular species and its parasites, etc. Another excellent account concerning lac cultivation is by S. Mahdi Hassan, 1919.

The male and immature stages of this species have been described by both Green (1922) and Imms and Chatterjee (1915), as well as by some other authors.

Metatachardia, subgen. n.

Orthotype.—*Tachardia conchiferata*, Green; Ceylon.

Diagnosis.—*Antennae of long type; spiracles not reversed; anal tubercle composed of a short hispid supra-anal plate and an elongate, lightly chitinised, pre-anal plate.*

Remarks.—This group, including so far as known the single species *conchiferata*, is remarkable in the many ways in which it suggests the subgenus *Tachardiella*, as, for example, in the simplex marginal duct clusters, the great development of the ventral clusters, the long antennae, the anal tubercle (exclusive of the fringe), as well as in other less obvious ways.

Metatachardia conchiferata, Green (Plates xi, I, P, GG; xii, B, M; xiii, A, H, J, Q; xiv, E).

1922—*Tachardia conchiferata*, Green, Coccidae of Ceylon. v, 407–408, Plate clxx.

Type Host and Locality.—Not definitely stated. See following.

Previous Records.—From Green, 1922: "On *Mimosa* sp., *Anona palustris*, *Excaecaria agallocha* and *Croton lacciferum*. Kandy; Matale; Jaffna; Tangalla."

Material Examined.—Ceylon, on *Anona palustris*, labelled type material; Ceylon: Matale, on *Croton lacciferum*; Jaffna, on *Excaecaria agallocha*; Ceylon, on *Mimosa* sp. All material from Green.

Habit.—From Green, 1922: "Resinous test of adult females globose or approximately hemispherical, smooth above with six deep depressions above the marginal area, each surrounded by prominent radiating ridges forming a definite and graceful shell-like pattern. . . . Colour bright castaneous, partly due to the colour of the contained insect, the lac being semi-translucent. Diameter of isolated tests, 4–6 mm.

"This species is much less abundant than *T. albizziae*. The resin is considered to be superior and is greatly valued by the lac workers of Matale and Tangalla, who distinguish it by the name of 'Tela-kiriya laccada.'"

Morphology.—Antennae long, apparently four-segmented, tipped by four setae (Plate xiii, Q); brachia heavily and rigidly chitinised, forming a long tube, which at the distal end is distinctly smaller than the greatest diameter of the truncate, cone-like brachial plate, giving it the appearance of being constricted behind the brachial plate (Plate xii, B); anterior spiracles large, more or less typical in shape (Plate xii, B₁), closely attached to base of brachia; posterior spiracles borne upon ovate rounded chitinous patches, as in *T. lacca*; dorsal spine as long externally as two-thirds the width of brachial plate, curicus in appearance by reason of a long internal, chitinous, tubular sheath which surrounds the ducts for a distance as great as the length of the spine itself (Plate xii, M); perivaginal pore clusters numerous and small, these smaller clusters in their turn grouping together in 7–8 closely associated larger groups, so that the impression given is that they consist of the more or less cracked or broken fragments of a comparatively few large clusters; marginal and ventral clusters arranged precisely as in *Tachardiella*, one pair being anterior to brachia and two pairs being posterior to them; marginal duct clusters consisting of a straight or slightly curved line of 9–12 evenly spaced tubular ducts (Plate xiii, H); anterior ventral duct cluster loosely clustered, of 50–60 small ducts; median ventrals 50–60 occupying a smaller area than anteriors; posterior ventrals more compactly

grouped, numbering 40-50; supra-anal plate extremely hispid, pre-anal plate smooth (Plate xiv, E); anal fringe apparently, but not surely, of the typical *Tachardia* type. Length 4-6 mm.

Remarks.—As before mentioned, this species shows most clearly the relationship of *Tachardia* to *Tachardiella*. It will be interesting to determine whether there are other undescribed species of this subgenus, or whether this is the sole survivor of this rather archaic group, also whether or no the brachial crater of this form is typically dimpled.

Undetermined Forms.

Tachardia sp. (Plate xi, H, K, U, V, W, JJ).

Material Examined.—A single lot, apparently all second stage larvae, from Ako, Formosa, on *Citrus* sp. Material from E. O. Essig, of the University of California.

Morphology.—Antennae very small, segmentation obscure, tipped by four setae (Plate xi, JJ); spiracles very small (Plate xi, U, V); brachial plate remarkably small, with 3-4 small dimples, which, unlike those of the second stage larva of *T. fici*, are well differentiated (Plate xi, K); brachia apparently absent; no trace of dorsal spine or perivaginal pore clusters; spiracles normal in position; marginal clusters of a true although obscure duplex type, strongly suggesting those of *Tachardiella*; all marginal clusters divided into two parts as in *Austrotachardiella*; anterior and median ventral clusters fairly well defined and composed of from 18-20 ducts; posterior ventral duct cluster lanceolate, elongate, and of 24-25 ducts; anal tubercle as in *Tachardiella* or *Metatachardia*, with a pre-anal plate; anal fringe typical of *Tachardia* (Plate xi, H). Length 1.0 mm.

Remarks.—It is my present belief that this rather unusual form is the second stage larva of probably an undescribed species of *Tachardia*, although the brachial plates strikingly suggest maturity. This form unquestionably belongs to *Tachardia* and probably to the subgenus *Metatachardia*. From its numerous striking resemblances to *Tachardiella* it lends some of the strongest support for the theory that *Tachardia* is a derivative of *Tachardiella*-like ancestors, which probably entered Asia along the very route upon which it would be likely to leave such a remnant as this, i.e., from the north down the Japanese archipelago, Formosa, China, Philippine Islands, etc.

Tachardiella, Cockerell.

(Plates x, A; xi (part); xv; xvi; xvii; xviii; and text-figs. 1, 2, 3, 4, 5.)

1901—Cockerell, *The Entomologist*. xxxiv, 249.

1903—Fernald, *Cat. Coccidae*. 123.

1921—MacGillivray, *The Coccidae*. 153.

Orthotype.—*Tachardia cornuta*, Ckll.; south-western United States and northern Mexico.

Diagnosis.—*Antennae* long; *crater* shallow, non-dimpled; *perivaginal pore clusters* always present and four in number; *anal fringe* consisting of more or less elongate ligulate lobes.

Morphology.—Antennae of the same relative length throughout the genus, whether the number of *evident* segments is large or small (3-7), and always tipped with from 4-7 or 8 setae; brachia well developed in most if not all cases and often with a deep constriction behind the brachial plate; brachial crater, as a rule, more or less ovate in form and rarely deeper than the breadth of the depression itself, always surrounded by a collar or flat rim of specifically variable width; anterior spiracles usually large, often exceeding the brachial plate in size; canellae present in many of the species, it being in this genus that these structures reach their greatest development; legs often, and possibly always, present as minute vestiges, occasionally, as in *T. parva* (Plate xviii, v), even showing traces of segmentation; dorsal spine always present,

its ducts always of the finely branching dendritic type; perivaginal pore clusters four in number and present in all known species, although in *T. lycii* they are so greatly reduced, often being represented by no more than a single pore and more rarely even absent in part, that it would not be surprising to find a species where they have entirely disappeared; three pairs of marginal duct clusters invariably present, one pair anterior to the brachia and two pairs posterior to them; occasionally marginal clusters secondarily divided so as to give the superficial appearance of six pairs of clusters; three pairs of ventral clusters usually present, although the posterior pair may occasionally be absent; dorsal ducts present or absent; anal fringe consisting of ligulate lobes, either of a long or short type, depending upon the subgenus; anal tubercle composed of a supra-anal plate, or rather collar, which bears the fringe, while preceding it in most species is a much less chitinated or occasionally membranous pre-anal plate; the anal ring distinctly quadrately sectoried in all observed cases.

Remarks.—This is apparently the "central genus" of the subfamily, and it is my personal conviction that there is evidence seeming to indicate it as most closely resembling the common ancestor of the subfamily. This hypothesis is dealt with in detail under the "remarks" following the generic descriptions. As may be easily noted by careful study of the characters possessed by this genus, there appear some anomalous features that are most easily considered as survivals from a more archaic type, which combined all of them in some measure, e.g., the appearance of pseudospines in *T. lycii*, as well as other features taken up in their appropriate positions under species headings. At any rate, assuming an ancestor combining the traits now found and demonstrated in this genus, it would be far easier to derive all other genera from it than from a similar hypothetical ancestor based upon a combination of characters found in any other genus or group. Similarly, the geographical distribution of the genera is more easily explained, it seems to me, by locating the point of origin in southern North America and Central America than is the case by placing it anywhere else. (See under *Tachardiina*.)

Tachardiella is divided into two distinct subgenera on the basis of several good and non-intergrading characters. In some respects, perhaps, they could be regarded as full genera, but this would obscure their intimate relationship, which I think is best expressed by means of the subgeneric concept. They may be separated by means of the following key:—

1. Anal fringe almost as long as anal ring setae; marginal duct clusters triplex .. *Austrotachardiella*, n. p. 187
- Anal fringe short, never nearly as long as anal ring setae; marginal duct clusters simplex or duplex, never triplex *Tachardiella*, Ckll. p. 174

***Tachardiella*, Cockerell, subgenus typicus.**

(*Short-fringe group*.)

Orthotype.—*T. cornuta*, Ckll.; south-western United States and northern Mexico.

Diagnosis.—Anal fringe on either side of anal cleft, consisting of four alternate, short, flaring, more or less tridentate lobes and an equal or nearly equal number of acute dentate processes; marginal duct clusters of simplex or duplex, but never of triplex types.

Remarks.—In addition to the above characters, the subgenus, as a rule, is characterised by the presence of comparatively much smaller perivaginal pore clusters than *Austrotachardiella* (compare Plate xvi, L and P with O). The dorsal spine likewise is on the average somewhat shorter than in *Austrotachardiella*, rarely exceeding in length the diameter of the brachial plate. The canellae are typical of this group, being present in some degree at least in all species so far known. Dorsal duct clusters are also almost typical, being found in all known species, excepting possibly *larreae* and *ingae*.

In its turn the subgenus is divisible into several well-marked groups, which will be discussed under their proper headings.

The species and forms may be separated by means of the following key. This is a very difficult group, and very close and careful study is required even to find some of the characters that it has been found necessary to use. However, with good material and some experience, there should be no particular difficulty in determining any of the following forms:—

1. Brachial crater large, ovate; showing at one end distinct indications of sub-depressions or pseudodimplings (Plate xv, A) .. *ingae*, Hempel. p. 176
Brachial crater not as in *ingae* 2
2. Rim of brachial crater distinctly broader, at least in some places, than the width of the crater itself 3
Rim of brachial crater only about half as broad as width of crater itself .. 5
3. Crater elongate, subovate (Plate xv, B, C) 4
Crater almost truly circular (Plate xv, D) *lycii*, Leon. p. 186
4. Marginal clusters very distinctly of the duplex type (Plate xvii, A)
texana, sp. n. p. 186
Marginal duct clusters of the simplex type, or at least the duplex character is very indistinct *mexicana*, Comst. p. 185
5. Dorsal ducts large and very prominent, always more than twice as great in diameter as a canellus pore and measurably larger than a perivaginal pore; posterior pair of ventral duct clusters absent or not evident
cornuta, Ckll. p. 182
Dorsal ducts never so large and prominent, never twice as large as a canellus pore and never more than subequal to a perivaginal pore; posterior pair of ventral duct clusters present or absent 6
6. Posterior ventral duct clusters always present and well marked 7
Posterior ventral duct clusters never present or at most represented by two or three minute scattered ducts 9
7. Marginal duct clusters duplex; with but two nuclear ducts; posterior ventral ducts not definitely clustered, but loosely spread out over an area several times larger than area of anterior spiracle *parva*, Hemp. p. 184
Marginal duct clusters simplex or duplex; "nuclear" ducts never less than 5 and usually 6-7; posterior ventral ducts definitely grouped into a cluster smaller in area than anterior spiracle 8
8. Dorsal ducts distinct, subequal to a perivaginal pore, arising from small circular chitinous patches which surround each individual duct; posterior ventrals closely grouped and closely associated with the duplex marginal duct clusters (Plate xvii, G) *fulgens*, Ckll. p. 183
Dorsal ducts obscure and not so "collared," always measurably smaller than a perivaginal pore; posterior ventrals not so closely associated with marginal duct cluster, which is apparently simplex *ferrisi*, sp. n. p. 183
9. The duplex type of marginal duct clusters plainly evident; with minute scattered tubular ducts around marginal and ventral clusters; canellae and canellar pores prominent 10
The duplex type of marginal duct clusters not evident; without minute scattered ducts around marginal and ventral clusters; canellae much reduced and inconspicuous 12
10. Canellae thin and straggling, without rather prominent expansion near mouth parts; without tendency to connect anterior with posterior spiracles (Plate xviii, M); anterior ventral cluster usually divided into two distinct parts
pustulata, Ckll. p. 179

Canellae not straggling and with a distinct expansion in the vicinity of mouth parts; distinct tendency to connect anterior and posterior spiracles; anterior ventrals undivided 11

11. Median ventral duct cluster very compact and composed of 8-14 ducts *glomerella*, Ckll. p. 180

Median ventral duct cluster rather loosely organised and composed of from 20-25 ducts *baccharidis*, f. n. p. 181

12. Dorsal ducts apparently not present or at least extremely inconspicuous; posterior marginal duct cluster composed of 4-5 ducts *larreae*, Comst. p. 177

With at least a few dorsal ducts present, each of which arises from a little chitinous collar, as in *fulgens*, although in no case are they as conspicuous as in that species (Plate xvii, z); posterior marginal duct cluster composed of 8-10 ducts *californica*, f. n. p. 179

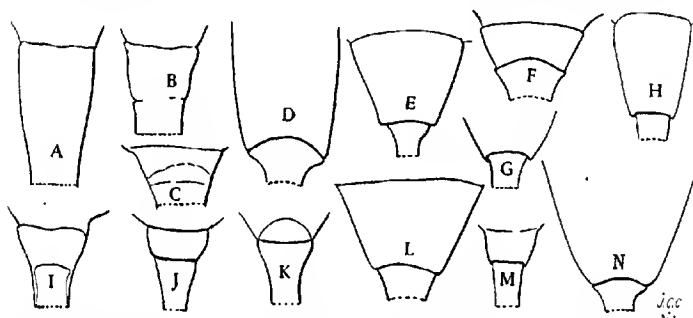


Fig. 3. *Austrotachardiella* and *Tachardiella*. Diagrams showing comparative sizes and shapes of anal tubercles:—

- | | |
|---------------------------|--------------------------|
| A. <i>T. texana</i> . | H. <i>T. cornuta</i> . |
| B. <i>T. mexicana</i> . | I. <i>A. cydoniae</i> . |
| C. <i>T. parva</i> . | J. <i>A. bodkini</i> . |
| D. <i>T. fulgens</i> . | K. <i>A. gemmifera</i> . |
| E. <i>A. rubra</i> . | L. <i>T. lycii</i> . |
| F. <i>T. ingae</i> . | M. <i>A. nigra</i> . |
| G. <i>T. glomerella</i> . | N. <i>T. larreae</i> . |

(All to the same scale.)

Group of *T. ingae*.

(*The pseudodimpled crater group.*)

Remarks.—This group includes only the isolated species *T. ingae*, and is characterised principally by the peculiarly pseudodimpled crater of the brachial plate (See Plate xv, A.). Crater without a crest.

Tachardiella ingae, Hempel (Plates xv, A; xvii, C; xviii, Q, AA; and text-fig. 3, F).

1900—*Tachardia ingae*, Hempel, Rev. Mus. Paul. iv, 415.

1901—*Tachardia ingae*, Hempel, Ann. Mag. Nat. Hist. (7), vii, 124.

Type Host and Locality.—From Hempel, 1901: "On branches of *Inga* sp., growing along the banks of the river Mogy-guassú, near the town of Mogy-guassú, State of S. Paulo, Brazil."

Material Examined.—A slide from Cockerell labelled as follows: "*Tachardia ingae*, Hempel. Type." Also material from Green labelled: "On ? Brasil. Ex. col. Hempel." All probably type material.

Habit.—The following is from Hempel, 1901: "Adult female scale subglobular, dorsum slightly flattened, with an aperture in the centre. The lac is dull, shiny when the surface becomes rubbed, semi-transparent, thick, brittle, light green with brown stripes. . . . The lac of many individuals usually unites to form a confused mass. Diameter 5.25 mm.; height 3.75 mm. Denuded of lac the insect is three-lobed. . . . This insect is peculiar in appearance and resembles a berry or seed so closely as to be deceiving." Old material is a light Indian red in colour.

Morphology.—Antennae distinctly seven-segmented; brachia lightly chitinised and fairly distinct; brachial plate almost circular, crater without a crest broadly ovate-oblong, half as wide as long and much wider than surrounding collar, one longitudinal half of crater subdepressed into pseudodimples (Plate xv, A); anterior spiracles large, about two-thirds the size of brachial plate and bearing numerous pores (Plate xviii, q); canellae prominent (Plate xviii, q); posterior spiracles with 7-8 pores; legs comparatively large, almost as large in fact as posterior spiracles (Plate xviii, AA); dorsal spine straight and shorter than width of brachial plate; perivaginal pore clusters large, measuring considerably more in diameter than half the width of anal tubercle at fringe and with considerably more pores than is typical of this subgenus; marginal clusters apparently of the simplex type, of about six ducts (Plate xvii, C₁); ventral duct clusters distinct, anterior ventrals with 25-30 loosely clustered ducts (Plate xvii, C₂), median ventrals of about 35 loosely grouped ducts, posterior ventrals of about 25 loosely grouped ducts; anal tubercle and supra-anal plate more or less generically typical, but basally a trifle broader than usual (text-fig. 3, F). Length 3-3.5 mm.

Remarks.—This species occupies an isolated position, and it is difficult to state its true relationship with other species. It unquestionably belongs with the short-fringe group of species and suggests in some ways a transitional type between *Tachardiella* and *Tachardia*. Personally, it appears to me to form a group of a rank equivalent to, say, the "narrow-collared group" of *Tachardiella* at least. There is no possibility of mistaking it for any other lac insect known to me.

Group of *T. cornuta*, Cockerell.

(*The narrow-collared group.*)

Remarks.—Characterised by an ovate, non-subdepressed crater, without a crest at one end and with a rim or collar which is never so wide as breadth of crater, usually no more than half as wide (Plate xv, E to G).

This entire "narrow-collared group" is an extremely homogeneous one, and all the species in it are closely related to one another, in consequence of which it is a very difficult group in which to make accurate determinations. The whole group requires careful study based upon a much larger quantity of material than has been available to me.

Subgroup of *T. larreae*, Comstock.

Remarks.—This subgroup is characterised by small perivaginal pore clusters (measuring much less in diameter than width of anal tubercle at fringe); by an elongate anal tubercle (text-fig. 3, X); by the absence of distinct posterior ventral duct clusters and by the very narrow brachial collar, which is never so wide as half the width of the crater.

Tachardiella larreae, Comstock, forma typica (Plates xi, A, B, D, J, O, Z, II; xv, H, I; xvi, P, R; xvii, U; xviii, H, L, X; and text-fig. 3, X).

1882—*Carteria larreae*, Comst., Rep. U.S. Dep. Agr., 1881. 211.

1883—*Carteria larreae*, Blanchard, Les Coccides utiles. 50.

1886—*Carteria larreae*, Signoret, Bull. Soc. Ent. Fr. (6), vi, 48.

1889—*Carteria larreae*, Riley, Ins. Life. i, 345.

- 1893—*Carteria larreae*, Targioni-Tozzetti, Contr. l'étude Gom. laques. 119.
 1894—*Tachardia larreae*, Cockerell, Can. Ent. xxvi, 31.
 1895—*Tachardia larreae*, Howard, Ins. Life. vii, 369.
 1897—*Tachardia larreae*, Howard, U.S. Dep. Agr., Bull. 9, n.s. 38.
 1899—*Tachardia larreae*, Cockerell, Ariz. Exp. Sta., Bull. 32. 258.
 1919—*Tachardia larreae*, Ferris, Journ. Econ. Ent. xii, 330-33.

Type Host and Locality.—"South-western portion of the United States and Mexico," on *Covillea glutinosa* (formerly *Larrea mexicana*).

Previous Records.—Ferris in his investigations concerning this insect gives the following distributional records. I quote from him. "The insect was not encountered in New Mexico, and I am informed by Professor Cockerell, who is more familiar with the scale-insect fauna of New Mexico than is any one else, that he has never seen it there. Elsewhere it is found throughout the entire area traversed. It was first encountered near Palm Springs, California, and was present constantly along the road from Mecca to Blythe, thence to Yuma, and from Yuma to Tucson by way of Ajo. It was not seen east of Tucson, but in returning it was encountered again at Rice, Arizona, and then from Phoenix to Parker it was relatively abundant. It was also present along the road from Parker to Needles and from Needles to Barstow. The last specimens were seen at Inyokern, near the southern end of the Owens Valley in California."

Some of the specimens listed in the above paragraph will fall under *T. larreae* f. *californica* n.

Material Examined.—California: 14 miles east of Shaver's Well; east of Mecca; near Mecca; Victorville (from Cockerell); Cabazon, San Bernardino County—all on *Covillea glutinosa*. Arizona: near Parker; 33 miles east of Ajo on Comoyo Road; Rice—all from *Covillea glutinosa*. All above material collected by G. F. Ferris unless otherwise stated. There is one slide in the collection labelled as from "*Larrea mexicana*" without date, collector, or locality.

Morphology.—Antennae of six evident segments (Plate xvi, R); brachia (Plate xv, L) and brachial plates (Plate xv, H) typical; anterior spiracles normal in shape and subequal to brachial plate (Plate xviii, H); with 45-50 pores; canellae not at all conspicuous, consisting of from 35-40 scattered star pores; posterior spiracle with 9-10 pores; legs very much reduced, represented by the tip of the vestigial claw (Plate xviii, X); dorsal spine as long as diameter of brachial plate; perivaginal pore clusters small (Plate xvi, P), varying in diameter from half to more than half width of anal tubercle at fringe; anterior and posterior clusters subequal; marginal duct clusters with 5-6 nuclear ducts of the duplex type (Plate xvii, U₁, duplex ducts not shown), but it is only in the very best preparations and with very careful observation that the duplex character is observable; anterior ventral duct cluster (Plate xvii, U₂) loosely grouped, more or less annular, of 25-30 ducts; median ventrals similar, of 20-22 ducts; posterior ventrals absent; dorsal ducts apparently, but not surely, absent; anal tubercle (text-fig. 3, N) somewhat more heavily chitinised than is usual; supra-anal plate typical, pre-anal plate usually staining rather deeply. Length 2.5-3.5 mm.

Remarks.—This form is very closely related to *larreae* f. *californica* n., and it may be later proved that they are not in reality separable from each other. However, in view of the fact that there are recognisable differences between them, it has been deemed best to regard them as distinct. As a pure speculation, it might be thought that such slight differences as show are merely due to the effect of a different host, and hence in some degree, environment, upon the same animal. However, the only way to settle such a question is by direct transference experiments, and until this is done the true status of these two forms must be regarded as provisional. Certainly, judging from analogy with other members of the COCCIDAE, the effects of different hosts are slight.

Differences between typical *larreae* and *f. californica* are dealt with in the morphological discussion of the latter form.

There have been numerous speculations regarding the commercial possibilities of this species as a lac producer. As a result Ferris conducted some investigations, which definitely showed that its commercial value was nil. I quote from Ferris, 1919:—

"Owing to the conspicuous appearance of the insect, its discovery, when it is present in any significant numbers, is a simple matter. Fairly accurate observations can, in fact, be made from a moving car. The lac occurs as a more or less solid incrustation on the twigs of the host plant, which is a very open shrub. The insects are extraordinarily gregarious and are almost never found singly, the colonies being from a quarter of an inch to a foot long. It appears that ordinarily the 'crawlers' merely move out toward the tip of the twig, thus increasing the length of the colony.

"The lac evidently remains upon the branches for a year, and probably much longer, for dead bushes were observed to which it was still clinging. Because of this it would seem reasonable to assume that occasionally plants would be found entirely covered by the insect. As a matter of fact nothing of the sort was ever seen, even in those localities where the insect is most abundant. In no case was a bush observed to have been killed by the scale, and in but a few cases were more than two or three of the entire total of many feet of branches on a bush infested. It is this occurrence in closely massed colonies that causes an entirely fictitious appearance of abundance in museum specimens. Five inches of heavily incrustated twig in a bottle will call up pleasing visions of acres of bush thus infested, but this may have been the site of the only colony in an acre of creosote bush."

Tachardiella larreae f. californica, n. (Plates xv, k; xvii, v, y).

Type Host and Locality.—California: Shaver's Well, near Mecca, on *Peucephyllum shottii*, summer, 1918 (G. F. Ferris).

Other Records.—A lot of lac insects belonging to this group, without data of any kind, is doubtfully referred to this form, although in some respects it is more similar to the typical form. (See under "Remarks.")

Habit.—Very similar to *larreae*, the lot of material mentioned above as being without data, being particularly like the typical form. Lac somewhat rougher than that of *larreae*, pale dragon's-blood in colour, and apparently powdered with ash.

Morphology.—Antennae as in *larreae*; brachia and brachial plates similar to *larreae*, but plates distinctly larger (Plate xv, k); anterior spiracle of typical shape, somewhat smaller than brachial plate, with about 45 pores; canellae somewhat more distinct than in *larreae*, of 40–45 pores; posterior spiracle with 23–25 pores; dorsal spine as long as brachial plate; perivaginal pore clusters usually half as long as width of anal tubercle at fringe, anterior and posterior clusters subequal; marginal duct clusters of a somewhat more distinct duplex type than in *larreae*, with 10 or 11 nuclear ducts (Plate xvii, v₁); anterior ventrals of 42 or 43 ducts (Plate xvii, v₂); median ventrals very compact, of 14–15 ducts; with dorsal cluster of pores distinctly present, although rather small and somewhat difficult to find; dorsal ducts "collared" as in *fulgens*, but much less prominently (Plate xvii, y); anal tubercle as in *larreae*. Length 4.0 mm.

Remarks.—*T. larreae* (including both forms) is apparently most closely related to the small group made up of *T. glomerella* and *T. pustulata*, being with little doubt most closely allied to the latter species.

Tachardiella pustulata, Cockerell (Plates xv, o; xvi, j; xvii, R, S, W, X, Z; xviii, M, M₁).

1895—*Tachardia pustulata*, Ckll., Psyche. vii, Suppl. 1, 2.

1895—*Tachardia pustulata*, Ckll., Proc. Ent. Soc. Lond. 21.

Type Host and Locality.—I quote from Cockerell: "*T. pustulata* was found by Prof. Toumey near Phoenix, Arizona, early in the spring of 1894. It occurred on a small perennial composite which was unknown to Prof. Toumey, and being without flowers or fruit could not be identified. It has linear leaves."

Material Examined.—Part of Cockerell's type material received from Mr. Harold Morrison, of the National Museum. Arizona: Phoenix (Mormon Flat), on *Baccharis* sp. (*G. F. Ferris*). California: Los Angeles, on *Bigelovia brachylepis*; from Morrison. This latter specimen is retained under this name, although differing in some details. Arizona, on unknown host; material from Ehrhorn.

Habit.—Verbatim from Cockerell: "Female scales more or less massed together, sometimes single, deep crimson, about the colour of black-currant jelly, moderately shiny, with small pellucid pustule-like prominences." Length about 3.5 mm., height 2.5 mm.

Morphology.—Antennae similar to *glomerella* (Plate xvi, j); brachial plates typical, somewhat intermediate in size between *glomerella* and *baccharidis* (Plate xv, o); anterior spiracle subequal to brachial plate, with 30–35 pores (Plate xviii, m); canellae much less distinct than in either *glomerella* or *baccharidis*, approaching *larreae* (Plate xviii, m), with 24 star pores; posterior spiracles with 6–7 pores (Plate xviii, m₁); posterior perivaginal pore clusters distinctly larger than anterior, posterior with 18 pores, anterior with 7–8; dorsal spine 1.2 times as long as breadth of brachial plate; anterior marginal duct cluster of true duplex type, with 5–6 nuclear ducts; median marginals with two or three truly nuclear ducts and one or two outlying ducts of the same type (Plate xvii, s); posterior marginals with five nuclear ducts, duplex and altogether similar to *glomerella* and *baccharidis* (Plate xvii, s); anterior ventral duct cluster divided usually into two parts, each part with 18–19 ducts (Plate xvii, w), although in a specimen from Los Angeles, California, referred to this species this cluster is entire, being composed of 18–19 ducts, the other half apparently being lost; median ventrals very compactly grouped, of 15 or 16 ducts, which present peculiar elongated openings as seen from a dorsal position; posterior ventrals absent or perhaps represented by the minute, scattered, tubular ducts found near the posterior marginal cluster (Plate xvii, r₁) (in some ways these ducts more nearly suggest scattered ducts of the same type that form the border of the triplex clusters of *Austrotachardiella*); dorsal ducts present, each with a slight but distinct chitinous collar as in *T. californica* (Plate xvii, z); dorsal tubercle as in *glomerella*. Length 2.5 or 3 mm.

Remarks.—This species is somewhat intermediate between the *larreae-californica* aggregate and the *glomerella-baccharidis* aggregate, but is with little doubt most closely related to the latter group, as shown by the similarities in the marginal and ventral duct clusters, etc.

Tachardiella glomerella, Cockerell, forma typica (Plates xi, y, aa; xv, n, p; xvi, k, q; xvii, j, k, m, n; xviii, x, o; and text-fig. 3, g).

1905—*Tachardia glomerella*, Ckll., Ent. News. xvi, 52.

Type Host and Locality.—New Mexico: on the "mesa" near Little Mountain, Mesilla Valley, on *Gutierrezia glomerella*, Green, 6th October 1904 (*Dr. David Griffiths*).

Material Examined.—New Mexico: Part of type material. Texas: Falfurias, on unknown composite; Sheffield, near Pecos River, on *Gutierrezia* sp., summer of 1921 (*G. F. Ferris*). California: Whittier, on "sage brush" (*Adenostoma* sp. (?)). Material from Ehrhorn.

Habit.—Solitary or massed on twigs. Lobation distinct; lac clear and translucent, amber-like; near dragon's blood in colour.

Morphology.—Antennae of five segments (Plate xvi, k); brachia (Plate xv, p) and brachial plates (Plate xv, n) distinctly smaller than in *baccharidis* but entirely typical in structure; anterior spiracle typical in shape and subequal to brachial plate (Plate xviii, n), with 30-35 pores; canellae distinct, composed of from 27-30 prominent star pores (Plate xviii, n); posterior spiracles very close to ends of canellae and almost connected with them, with 9-12 pores; dorsal spine 1.3 times as long as width of brachial plate, often basally bent; perivaginal pore clusters about subequal in diameter to width of anal tubercle at fringe, posterior perivaginal clusters distinctly a little larger than anteriors; marginal duct clusters distinctly duplex in character; anterior marginals with 4-5 nuclear ducts; median marginals with 2-4 nuclear ducts (Plate xvii, j); posterior marginals with 4-5 nuclear ducts; anterior ventral duct cluster prominent, of about 25 conspicuous ducts loosely grouped into two parts (Plate xvii, m); median ventral cluster very compact and consisting of 6-8 ducts (Plate xvii, x); posterior ventrals absent; in addition to the usual marginal and ventral ducts there are numbers of very small tubular ducts scattered sparingly around the clusters; dorsal duct cluster present, each duct with a very indistinct trace of a chitinous base or collar, never so distinct as in *californica* or *pustulata* (Plate xvii, k); dorsal tubercle subgenerically typical (text-fig. 3, g). Length 2-3 mm.

Remarks.—This species (including *baccharidis*, f.n.) is without doubt most closely related to *T. pustulata*, although, as may be seen by comparison of the descriptions, they are easily distinguishable. Perhaps the most striking difference between this species and the others of this group is the character of the canellae, which are rather prominent in this species and show a distinct and perhaps significant tendency to connect with the posterior spiracles (Plate xviii, n, p). Also the canellae in *pustulata* and the *larreae-californica* aggregate are comparatively much longer than in *glomerella-baccharidis* (compare Plate xviii, m with n and p).

Tachardiella glomerella f. *baccharidis* n. (Plates xv, Q; xvi, T; xvii, L, P, Q; xviii, p).

Type Host and Locality.—Texas: Tornillo Creek, between Marathon and Glenn Springs, on *Baccharis* sp. Collected by G. F. Ferris in 1921.

Other Material.—Texas: flats near Point Isabel, on undetermined composite. Collected by G. F. Ferris, summer, 1921.

Habit.—Very similar to that of *glomerella*; sometimes massed in such a way as to suggest *larreae*; lobation of test distinct, although not so clear as in *glomerella*; lac between an Indian red and dragon's blood in colour. Some lac that has weathered to a considerable extent is almost black.

Morphology.—Antennae of six evident segments, differing from those of *glomerella* by their much larger size (Plate xvi, t); brachia and brachial plates (Plate xv, q) typical; anterior spiracles subequal to brachial plate and bearing 55-60 pores (Plate xviii, p); canellae considerably more prominent than in *glomerella* (Plate xviii, p), composed of 60-65 pores and definitely connecting anterior and posterior spiracles; posterior spiracles with 10-15 pores; dorsal spine 1.2 times as long as breadth of brachial plate; perivaginal pore clusters subequal to each other, somewhat greater in diameter than half the width of anal tubercle at fringe; marginal clusters of duplex type; anterior marginal with 2-3 nuclear ducts, as is the case with median cluster (Plate xvii, i); posterior marginal usually with three nuclear ducts; anterior ventral duct cluster prominent (Plate xvii, p), annular in form and composed of about 30 ducts; median ventral cluster very similar in shape and with approximately the same number of ducts (Plate xvii, q); dorsal ducts 10-12 and somewhat inconspicuous; anal tubercle as in *glomerella*. Length 2-3 mm.

Remarks.—This form differs principally from typical *glomerella* in the more prominent canellae, larger antennae and the larger number of ducts in the median ventral cluster (25–30 as compared with 6–8).

Tachardiella cornuta, Cockerell (Plates xv, E, I; xvi, A, D, L, M; xvii, F, O, T; xviii, B, E, G, U; and text-fig. 3, G).

1894—*Tachardia cornuta*, Ckll., Can. Ent. xxxvi, 284 and 344.

1901—*Tachardiella cornuta*, Ckll., The Entom. xxxiv, 249.

1921—*Tachardiella cornuta*, MacGillivray, The Coccidae. 154.

Type Host and Locality.—On *Parthenium incanum*, H.B.K., Little Mountain, Mesilla Valley, New Mexico. (A few miles from the Agricultural College.)

Previous Records.—Listed in the Fernald Catalogue as also occurring in "Mexico."

Material Examined.—Part of type material from Cockerell. From Chihuahua, Mexico, on "ceno chilocothe"; material also from Cockerell. Texas: Chisos Mountains; north-west base of Chisos Mountains; Mount Franklin, El Paso—all on "composite" and all collected by G. F. Ferris.

Habit.—Solitary or lightly massed on stem of host; solitary individuals show distinct lobations; lac somewhat variable in colour, between a burnt sienna and brown ochre.

Morphology.—Antennae of four chitinised segments (Plate xvi, M); brachia long, with a constriction behind brachial plate (Plate xv, I); brachial plates typical, with a narrower collar than in the other species of this subgroup (Plate xv, E); anterior spiracles distinctly smaller than brachial plate, longer than broad and bearing 25–30 pores (Plate xviii, B); canellae well developed, consisting of a single more or less convoluted line of star pores, which almost meet a little caudad of the mouth parts, composed of 35–45 pores; posterior spiracles with 4–5 pores (Plate xviii, G); legs represented by minute claws arising from circular, convex, nipple-like patches (Plate xviii, U); perivaginal pore clusters small, often smaller than half the breadth of anal tubercle at fringe, and rarely, if ever, larger than this, in some cases a cluster may be reduced to as few as four or five pores (Plate xvi, A, L); dorsal spine a little more than 1.5 times as long as diameter of brachial plate; marginal clusters consisting of a more or less lunate line of 4–7 ducts, clusters apparently of an obscure duplex type (Plate xvii, T); anterior ventral duct cluster loosely organised, composed of 9–12 ducts (Plate xvii, T₄); median ventrals compact, of about six ducts; posterior ventrals apparently absent or occasionally represented by one or two isolated ducts; dorsal duct cluster prominent, of 7–8 very large ducts, always measurably larger than a canellar pore (in one specimen the number of dorsal ducts in the cluster was doubled, there being 16 or 17 ducts present); anal tubercle of the usual short subquadrate type, while the pre-anal plate is large and distinctly elongate (text-fig. 3, G). Length 2 mm.

Remarks.—This species is apparently more or less intermediate between the *larreae* and the *fulgens* subgroups, but the practical absence of the posterior ventral duct cluster and the narrow brachial collar definitely place it in the former group. It most closely approaches the latter group in the large size of the dorsal ducts.

Subgroup of *T. fulgens*, Cockerell.

Remarks.—This group possesses small perivaginal pores and much the same type of anal tubercle as is found in the *larreae* subgroup, but differs in possessing a brachial collar that is decidedly wider than half the width of crater and by the presence of unmistakable posterior ventral duct clusters. It includes two species, *fulgens* and *ferrisi*.

Tachardiella fulgens, Cockerell (Plates xv, G; xvii, D, G; and text-fig. 3, D).

1895—*Tachardia fulgens*, Ckll., *Psyche*. vii, Suppl. 1, 1.

1895—*Tachardia fulgens*, Ckll., *Proc. Ent. Soc. Lond.* 21.

1899—*Tachardia fulgens*, Ckll., *Biol. Cent.-Amer.* 9.

Type Host and Locality.—Arizona (Tucson?) on *Sesbania* (?)

Previous Records.—Mexico: Sonora, Guaymas, on *Mimosa* or *Prosopis* and on *Coursetia*; Hermosillo, on *Coursetia glandulosa*. It is possible that the type host is *Coursetia axillaris* instead of *Sesbania*, as doubtfully recorded by Cockerell.

Material Examined.—Arizona: Tucson, on *Coursetia axillaris*, from C. T. Vorhies. Mexico: Sonora, on unknown host (Bremner Collection), and from hills near Huasihuas on "legume"; from Cockerell. From Sonora, on unknown host; material from Ehrhorn.

Habit.—Massed or solitary on twigs of host. Tests roughened and distinctly lobed, even when in masses; varying to some extent in colour, but approaching a chrome orange rather closely. The following rather interesting remarks are quoted from Cockerell's original description:—

"*Hab.* Arizona, received from Prof. J. W. Toumey, who gives the following interesting particulars. He got it from a Mexican, and has seen only the stem of the food-plant, but thinks it is a *Sesbania*. He was told that this lac was used quite extensively by the Mexicans as a medicine for stomach troubles, under the name of "Gomea" (Gomilla). It is kept in the drug shops at Tucson and meets quite a sale. It is also used to some extent in mending pottery, etc. Finally, he adds, the Mexicans make a marked distinction between this and *T. larreae*, the latter not being considered to have any medicinal qualities.

"It is certainly the most beautiful and striking lac I have ever seen."

Morphology.—Antennae of 6-7 evident segments; brachia as usual; brachial plates with collar as broad as in *ferrisi* (Plate xv, G); anterior spiracle typical in shape and subequal to the brachial plate, bearing 50-60 pores; canellae rather weakly developed, consisting of 16-25 star pores; posterior spiracles with 13 pores; dorsal spine as long as brachial plate; perivaginal pore clusters well developed, somewhat greater in diameter than width of anal tubercle at fringe; marginal duct clusters of a duplex type, anterior marginals of 4-6 ducts, with a few scattered minute tubular duplex ducts (much smaller than ventral ducts); median marginals as in anteriors; posterior marginals 8-9, closely associated with the posterior ventral duct cluster, while scattered closely around both marginal and ventral cluster are 30-40 of the small scattered duplex ducts before mentioned (Plate xvii, G); anterior ventral duct cluster of 16-18 loosely grouped ducts; median ventrals more closely grouped, numbering about the same; posterior ventrals very closely associated with marginals, closely grouped and numbering 8-10 ducts; distinct dorsal cluster of about eight large and rather prominent ducts, all of which arise from a comparatively large and rather prominent chitinous collar or rim (Plate xvii, D); anal tubercle as in *cornuta*, but with pre-anal plate larger and more flaring (text-fig. 3, D). Length 3 mm.

Remarks.—This species is most closely related to *T. ferrisi*, although certain characters, particularly the large size of the dorsal ducts, seem to suggest *cornuta*.

Tachardiella ferrisi, sp. n. (Plates xv, F; xvi, H, S; xvii, I; xviii, Z).

1921—*Tachardia* sp., Ferris, Stanford Univ. Pub. Biol. Sci. i. 86.

Type Host and Locality.—Mexico: Lower California, La Paz, on *Acacia flexicaulis*, July 1919 (G. F. Ferris).

Previous Records.—Recorded by Ferris as *Tachardia* sp. on *Acacia flexicaulis* from the following localities in Lower California, Mexico: La Paz, San Pedro and San Bartolo. All these localities are in what is known as the "Cape Region."

Material Examined.—Material from all localities recorded by Ferris with the exception of San Bartolo.

Habit.—Loosely massed upon twigs of host. Tests smooth and gently lobed; lac smooth and between dragon's blood and burnt sienna in colour, averaging, perhaps, a little darker than the latter.

Morphology.—Antennae of five evident segments (Plate xvi, s); brachia typical; brachial plates typical of the subgroup of *T. cornuta* (Plate xv, f); anterior spiracles subequal to brachial plate, with 50–60 pores; canellae very well developed, consisting of 35–50 star pores; posterior spiracles with 6–7 pores; legs very small, represented by a minute claw surmounting a tiny tuberosity (Plate xviii, z); dorsal spine as long as diameter of brachial plate, often basally bent or distorted (Plate xvi, n); perivaginal pore clusters about as great in diameter as half the width of the anal tubercle at fringe; marginal duct clusters very similar to those of *fulgens*, apparently not of a true duplex type (Plate xvii, 1₂), the very small tubular ducts much scarcer than in *fulgens*; anterior marginals 7; median marginals 5–6; posterior marginals 12–13, with also a few minute scattered ducts; anterior ventral ducts 32–34, arranged in a loose annular cluster (Plate xvii, 1₃); median ventrals loosely annular, of 14 or 15 ducts; posterior ventrals very closely grouped, of 15–16 ducts; the ventral posterior ducts especially notable on account of the peculiar manner in which the thread-like ducts arise from the main tube (Plate xvii, 1₄); dorsal duct cluster of 8 ducts, much less conspicuous than in *cornuta* or *fulgens* and not arising from chitinous collars; anal tubercle much as in *cornuta*, entirely typical. Length 2 mm.

Remarks.—This species in the character of the marginal and ventral clusters clearly shows its affinity with *T. fulgens*, the species to which it is apparently most closely related. They are easily separated, however, on the basis of numerous characters, and there is no reason for confusing the two.

Subgroup of *T. parva*, Hempel.

Remarks.—This subgroup, comprising but a single species, is the best marked division of the narrow-collared group of species and might be best considered as a division of a rank equivalent to all the other narrow-collared species combined. It is distinguished by the large perivaginal pore clusters; by the "stubby" anal tubercle (text-fig. 3, c), and by the small number (2) of nuclear ducts in the marginal clusters.

***Tachardiella parva*, Hempel** (Plates xv, j; xvi, f; xvii, n; xviii, v; and text-fig. 3, c).

1900—*Tachardia parva*, Hempel, Rev. Mus. Paul. iv, 413.

1901—*Tachardia parva*, Hempel, Ann. Mag. Nat. Hist. (7) vii, 122.

Type Host and Locality.—Brazil: State of Sao Paulo, Cachoeira and Ypiranga, on one of the Myrtaceae.

Material Examined.—One slide of type material. Loaned by Mr. Harold Morrison, of the National Museum.

Habit.—Verbatim from Hempel, 1901: "The younger females have a test of brown lac, elongate, with a tubercle in the middle of the dorsum and three processes on the lateral margin on each side. In the older specimens the test is globular and of an orange-brown colour. Specimens varying from 2.0–2.75 mm. long and 1.25–2.0 mm. high. The female denuded of wax has three conspicuous lobes on each side. Length about 1.25 mm., width 0.75 mm."

Morphology.—Antennae long, but with only about three rings of chitinisation; brachia apparently short; brachial plates typical, with comparatively broad rim, as in *ferrisi* and *fulgens* (Plate xv, j); anterior spiracles distinctly a little smaller

than brachial plate, with 35-45 pores; canellae prominent, composed of a regular, uniform band of 55-60 star pores; posterior spiracles with 4-5 pores; legs fairly large, with distinct traces of two segments and bearing a small claw (Plate xviii, v); dorsal spine rather slender, 1.4 times as long as width of brachial plate (Plate xvi, r); perivaginal pore clusters compact and larger than is typical in this group, being about thrice as great in diameter as width of anal tubercle at fringe; marginal duct clusters distinctly duplex, all with two nuclear ducts (Plate xvii, H₂); marginal cluster subequal in size to anterior spiracle; anterior ventral cluster, annular, closely grouped, of 20-25 ducts; median ventrals of 8-10 closely grouped ducts; posteriors grouped rather loosely, numbering about 30 and apparently of somewhat smaller ducts than the other ventral clusters; anal tubercle generically typical but of a much shorter type than *cornula* (text-fig. 3, c). Length 1.2 mm.

Remarks.—This species, as might be expected from its peculiar geographical isolation, is the most distinct of any of the included species of the "narrow-collared group."

Group of *T. mexicana*, Comstock.

(*The broad-collared group*.)

Remarks.—Characterised by an ovate or circular crater, which is non-pseudodimpled; crater bearing at one end an upright chitinous process or fringe such as is typically found in *Austrotachardiella* (in *T. lycii* (?)); crater never as broad as the widest portion of the crater rim (Plate xv, B, C, D).

This group is very sharply marked off from the narrow-collared group and seems more or less intermediate between it and *Austrotachardiella*. It includes, so far as known, but three species.

Tachardiella mexicana, Comstock (Plates xv, B; xviii, C, K, S, T; and text-fig. 3, B).

1882—*Carteria mexicana*, Comst., Rep. U.S. Dep. Agr. 1881, 212.

1883—*Carteria mexicana*, Blanchard, Les Coccides utiles. 51.

1886—*Carteria mexicana*, Signoret, Bull. Soc. Ent. Fr. (6). vi, lxii.

1893—*Carteria mexicana*, Targioni-Tozzetti, Contr. l'étude Gom. laques. 120.

1893—*Carteria mexicana*, Targioni-Tozzetti, On Species of Lacca. 31.

1898—*Tachardia mexicana*, Townsend & Cockerell, Jour. N.Y. Ent. Soc. vi, 173.

1899—*Tachardia mexicana*, Ckll., Biol. Centr.-Amer. ii, 2, 9.

1898—*Tachardia fulvoradiata*, Cockerell, Ann. Mag. Nat. Hist. (7). i, 431.

Type Host and Locality.—Mexico: Tampico, on "mimosa."

Previous Records.—Mexico: Oaxaca, on branches of *Mimosa* sp., also recorded from "Mexico: Rancho Carbonel, near Frontera," as *T. fulvoradiata*.

Material Examined.—Mexico: Oaxaca, on *Mimosa* (in Bremner Collection of Coccidae). Texas: Carrizo Springs, on *Acacia*; Brownsville and Phair, on *Acacia flexicaulis*. All Texas material collected by G. F. Ferris. A slide from Cockerell labelled "*T. fulvoradiata*—Type" was also examined.

Habit.—Tests single or massed, individual tests more or less stellately lobed, in masses lobation is lost; lac a clear Indian red, apparently darker in streaks.

Morphology.—Antennae of six segments; brachia and brachial plates typical of group, crater ovate (Plate xv, B); anterior spiracles large, with 95-100 pores, but nevertheless considerably smaller than brachial plate (Plate xviii, c); canellae very well developed, of 120-130 pores; posterior spiracles with 11 pores (Plate xviii, k); legs present and comparatively large, being almost as large as the posterior spiracles and showing no traces of segmentation (Plate xviii, s, t); dorsal spine rather variable in length, but never so long as the width of the brachial plate, and often but little more than half as long, in nearly all cases the spine is peculiar in that

there is a prominent basal bend to it, the few cases where it is apparently straight may be due to the way the spine is turned in the mount, but the probabilities are that it is truly variant from one to the other; perivaginal pore clusters but little larger than one-third of the width of anal tubercle at fringe; marginal duct clusters apparently simplex, but it is probable that they are really duplex, although this remains to be shown; all marginal clusters with 6-7 nuclear ducts; anterior ventral duct cluster more or less annular in form, of about 30 ducts; median ventrals similar to anteriors, of about 24 ducts and closely associated with the marginal cluster; posterior ventrals as in medians; anal tubercle distinctly longer than broad and showing only slight traces of a division between supra-anal and pre-anal plates (text-fig. 3, B). Length 2-3 mm.

Remarks.—This species and *T. fulvoradiata* are almost unquestionably synonyms, in which case, of course, the name *fulvoradiata* disappears. Although the greatest care was exercised in comparing the type slide of *T. fulvoradiata* with *T. mexicana*, not a single constant difference could be found, and the two are here regarded as identical.

T. mexicana is most closely related to *T. texana*, but is nevertheless very distinct therefrom. There is little reason for confusing the two, as may be seen by comparing the figures and descriptions.

***Tachardiella texana*, sp. n.** (Plates xi, C, KK, LL; xv, C; xvi, I; xvii, A; xviii, BB; and text-fig. 3, A).

Type Host and Locality.—Texas: Atosca County, Jordanton, on *Acacia* sp.

Habit.—In broken masses on stem of host. Old lac almost black. The lac of younger specimens might easily be similar to that of *mexicana*.

Morphology.—Antennae of six evident segments; brachia and brachial plates typical, craters ovate (Plate xv, C); anterior spiracles typical in shape and half the size of brachial plate, bearing 120-130 pores; canellae somewhat less developed than in *mexicana*, composed of about 100 star pores; posterior spiracles with 13-14 pores; legs "well" developed, being almost as large as the posterior spiracles and showing faint traces of segmentation (Plate xviii, BB); dorsal spine as in *mexicana* (Plate xvi, I); perivaginal pore clusters about half the width of anal tubercle at fringe; marginal duct clusters very decidedly of the true duplex type, all with 6-7 nuclear ducts (Plate xvii, A₂); anterior ventral cluster more or less annular in form and composed of about 22 ducts; median and posterior ventrals similar, more or less annular and fairly compact, of 15-18 ducts (Plate xvii, A₃); dorsal ducts probably absent; anal tubercle slenderer than in *mexicana* and without the slightest trace of a division between the pre-anal and supra-anal plates (text-fig. 3, A). Length 3 mm.

Remarks.—This species, which is fairly close to *mexicana*, is very easily distinguished therefrom by the very decided duplex character of the marginal duct clusters as well as by the more slender anal tubercle.

***Tachardiella lycii*, Leonardi** (Plates xv, D; xvi, N; xvii, B, E; xviii, R, CC; and text-fig. 3, L).

1911—*Tachardia lycii*, Leonardi, Bol. Lab. Zool. Sc. Sup. Agr. Portici. v, 256.

1919—*Tachardia lycii*, Morrison, Proc. Ent. Soc. Wash. xxi, no. 4, 75.

Type Host and Locality.—Argentina, on *Lycium chilense*.

Previous Records.—Morrison records this species from Mendoza, Argentina.

Material Examined.—Three slides from the U.S. National Museum, loaned by Morrison. From Mendoza, Argentina, on an unknown host. Morrison's determination.

Habit.—Unknown to me.

Morphology.—Antennae of 4-5 segments, somewhat stubby (Plate xvi, n); brachia not observed; brachial plates almost circular, with the small circular crater placed decidedly off centre (Plate xv, b); craters rather deep, the ceriferous pores apparently of a pseudospinous nature (Plate xx, d), although the converging processes are apparently somewhat slenderer; anterior spiracles large, being subequal to brachial plate and with very few pores (11 or 12) (Plate xviii, r); canellae distinct, pores more numerous terminally than centrally, totalling about 40-50 (Plate xviii, r); posterior spiracles with 3-4 pores; legs present as a moderately small peduncle bearing a fairly prominent although small claw (Plate xviii, cc); dorsal spine short, never longer than width of brachial plate and usually subequal to it; perivaginal pore clusters very much reduced, usually of 1-4 pores, although occasionally a cluster is entirely absent; marginal duct clusters duplex and divided as in some species of *Austrotachardiella*, so that there are apparently six pairs of clusters; each half of anterior and median marginals with two nuclear ducts; posterior marginals with three and two nuclear ducts respectively in each half (Plate xvii, b); anterior ventral duct cluster of about 16 loosely scattered minute ducts; median ventrals of 12 loosely grouped ducts; posterior ventrals of 5-7 minute ducts closely connected with posterior marginals (Plate xvii, b); dorsal ducts apparently absent; anal tubercle of typical structure except that pre-anal plate is broader than usual (text-fig. 3, l).

Remarks.—This unusual species is doubtfully referred to the *mexicana* group, although its structures are so divergent from this group as probably to entitle it to a co-ordinate rank. Its more unusual features are the divided duplex marginal duct clusters and the great reduction of the perivaginal pore clusters. The structure of the brachial plates is likewise divergent, being as they apparently are without the crest typical of *mexicana* and *texana* and with the ceriferous pores apparently of a pseudospinous nature.

Morrison makes the following interesting comment, which seems to indicate that *T. cordaliae* is a synonym of this species: "While it is of course impossible to make any definite statement, it appears to the writer, after a careful study of Leonardi's description of *T. cordaliae*, that it is very doubtfully distinct from the *T. lycii* described in the preceding pages."

***Austrotachardiella*, subgen. n.**

(Plates x, xi (part), xvi (part), xviii (part), and text-figs. 1, 2, 3 (part), 4, 5).

Orthotype.—*Tachardia rotundata*, Ckll. Mexico.

Diagnosis.—Anal fringe on either side of the anal cleft consisting of three long ligulate lobes, which are almost as long as the anal ring setae; marginal duct clusters all triplex.

Remarks.—In addition to the above important characters, the subgenus as a whole is characterised by a number of others, which may be stated as follows:—

On either side of the anal fringe is a seta as long as the lobes themselves; marginal duct clusters either entire or subdivided into two parts; always with three pairs of ventral duct clusters; canellae absent or much reduced, much less conspicuous than in *Tachardiella*; brachial crater shallow, more or less ovate and with a distinct raised crest at one end (text-fig. 4, A); dorsal spine on the average longer and slenderer than in *Tachardiella*, in the present subgenus being rarely shorter than 1.5 times the width of brachial plate; more or less characteristic is a pair of horse-shoe shaped internal chitinous apodemes in the pygidial region, directly ventrad of the dorsal spine (Plate xvi, c). In general, these apodemes are greater in extent than the anterior spiracle. No traces of these structures, which are certainly analagous, if not homologous, with the somewhat similar structures in some species of *Tachardina*, have been found in the subgenus *Tachardiella*. The perivaginal pore clusters average considerably larger than in *Tachardiella* (Plate xvi, o, as compared with p), being

rarely less in diameter than the width of the anal tubercle at the fringe, while in *Tachardiella* the reverse is the case. The anal tubercle differs only slightly from the typical *Tachardiella* form except in the unusual case of *T. (A.) rotundata*, which seems to be a law unto itself (Plate xvi, c).

The species of this subgenus may be separated by means of the following key:—

1. Marginal clusters paired or almost paired, with at most a narrow isthmus connecting the two parts 2
Marginal clusters entire, never with any deep constriction tending to subdivide them 4
2. The two parts of each marginal cluster connected by a narrow isthmus of pores and ducts (text-fig. 5, E) *bodkini*, Newst. p. 189
The two parts of each marginal cluster entirely distinct, never connected by an isthmus of pores 3
3. Brachia very heavily chitinised and strongly constricted behind brachial plate; without a visible annular band of dorsal ducts . . . *rotundata*, Ckll. p. 188
Brachia not heavily chitinised and without an obvious constriction behind brachial plate; with a distinctly visible annular band of dorsal ducts . . . *gemmifera*, Ckll. p. 191
4. Nuclear ducts of posterior marginal cluster 2; posterior ventral ducts numbering 14–15 *cydoniae*, Hempel. p. 193
Nuclear ducts of posterior marginal cluster usually 4, never 2; posterior ventral ducts numbering 30–50 5
5. Canellae distinctly present, although but weakly developed (50–60 star pores); lateral margin of crater bulging outward, outline evenly curved (text-fig. 4, G) . . . *rubra*, Hempel. p. 192
Canellae almost entirely absent (5 or 6 star pores); lateral margins of crater not so bulging, outline not evenly rounded (text-fig. 4, E) . . . *nigra*, Towns. & Ckll. p. 192

Group of *A. rotundata*, Cockerell.

Remarks.—This group is sharply marked off from the group of *A. rubra* by the distinct division (not complete in *bodkini*) of the marginal duct clusters; by the total absence of canellae; by the larger anterior spiracles and by the "broad collared" brachial plate (text-fig. 4, c) (crater never so broad as greatest width of collar).

Austrotachardiella rotundata, Cockerell (Plates xvi, B, C, G; xviii, D, F; and text-figs. 4, H; 5, F, G).

1903—*Tachardia rotundata*, Ckll., Ann. Mag. Nat. Hist. xi, 165.

Type Host and Locality.—Mexico: El Platanos, Jalisco, on "Zicna" and "Guasima."

Material Examined.—Part of type material, received from Cockerell.

Habit.—Verbatim from Cockerell: "Scale hemispherical, about 6 mm. long, 5.5 broad, 4 high; black, with a pink tint here and there, with a slight protuberance on each side, but not exhibiting the raised points of *T. gemmifera*; margin with short tongue-like processes."

Morphology.—Antennae of 5–6 segments; brachia very heavily chitinised, only a lateral aspect being obtainable from a slide preparation, strongly constricted behind the brachial plate, which is entirely typical of the subgenus (text-fig. 4, H); anterior spiracles large, as broad as diameter of brachial plate, more or less angular in shape

and almost as broad as long (Plate xviii, b) and bearing from 125–150 pores; canellae totally absent; posterior spiracles with 9–10 pores (Plate xviii, f); dorsal spine straight, evenly and narrowly acute and 1.5 times as long as width of brachial plate (Plate xvi, g); pygidial apodemes present and prominent (Plate xvi, c); perivaginal pore clusters large and saucer-like, almost 1.5 times as broad as width of anal tubercle at fringe; each subdivision of marginal duct clusters entirely independent, subovate and with 2–3 nuclear ducts (text-fig. 5, F₁); anterior ventral duct cluster, large and roughly annular in form, composed of 85–90 ducts; median ventrals also annular and with 55–60 ducts (text-fig. 5, F₂); posterior ventrals more compact, ovate, with 60–65 ducts; no annular band of dorsal pores, as in *gemmifera*; anal tubercle widely divergent from the typical form, consisting of a fairly long and slender chitinous process (four times as long as width at fringe) and with an enlarged or swollen ring just posterior to the anterior half (Plate xvi, c). Length 3–3.5 mm.

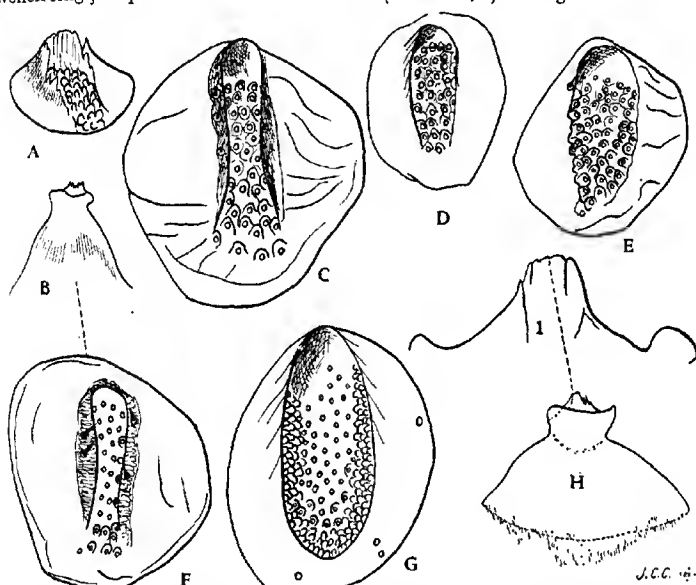


Fig. 4. *Austrotachardiella*. A. *A. cydoniae*, antero-lateral aspect of brachial plate, showing the crest at one end of the crater. B. *A. bodkini*, lateral aspect of brachium, showing crest of crater. C. *A. gemmifera*, brachial plate. D. *A. cydoniae*, terminal aspect of brachial plate. E. *A. nigra*, brachial plate. F. *A. bodkini*, brachial plate. G. *A. rubra*, brachial plate. H. *A. retundata*, brachium, lateral aspect; (1) crest of crater (same scale as brachial plates).

(All figures of brachial plates upon same scale of magnification.)

Remarks.—This species is fairly close to *bodkini*, from which it is easily distinguished by numerous good characters, such as by the completely divided marginal duct clusters and by the peculiarly shaped anal tubercle. From *gemmifera*, to which it is less closely allied, it may immediately be distinguished by the heavily chitinated brachia as well as by the anal tubercle.

Austrotachardiella bodkini, Newstead (Plate x, A; and text-figs. 3, J; 4, B, F; 5, C, E).

1917.—*Tachardia bodkini*, Newstead, Bull. Ent. Res. viii, no. 1, 18–19, 2 figs.

Type Host and Locality.—British Guiana: Georgetown, near Repos, on *Sapium jenmani*.

Material Examined.—Part of type material. From Green.

Habit.—After Newstead: "Obconical; centre with a bluntly pointed prominence, rarely two; margin with low, blunt and usually bifid processes, clearly the remnants of the rays of the test of the young female; surface smooth; a nipple-like prominence over the anal opening. Colour bright subtranslucent orange-red, or in certain lights faintly orange-ruby. Texture very hard and brittle, similar to that of the lac of commerce (*T. lacca*). Length 5.4 mm., height 3.3 mm.

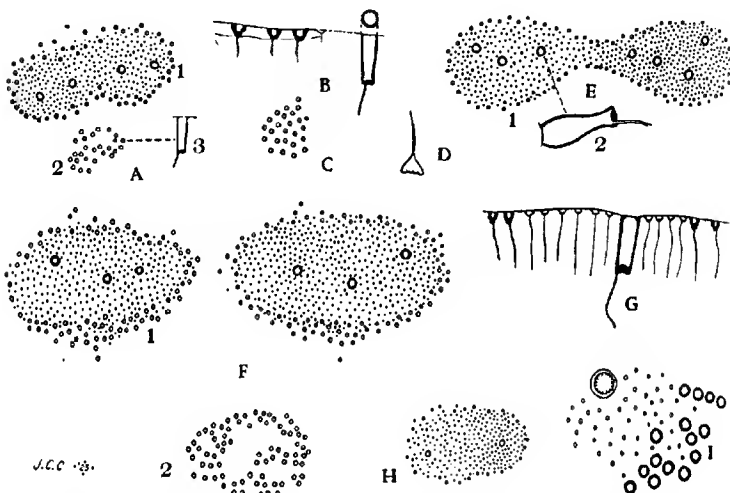


Fig. 5. *Austrotachardiella*. A. *A. nigra*, anterior marginal and ventral duct clusters; (1) marginal triplex cluster; (2) ventral cluster; (3) ventral duct. B. *A. nigra*, cross section through skin in region of marginal duct cluster, showing the lateral aspect of a nuclear duct, one of the duplex or spermatozoid ducts and the bordering triplex ducts. C. *A. bodkini*, ventral duct cluster. D. *A. bodkini*, internal termination of one of duplex ducts. E. *A. bodkini*; (1) marginal duct cluster illustrating the type intermediate between the entirely divided and the undivided types; (2) nuclear duct. F. *A. rotundata*, median marginal and ventral duct clusters; (1) marginal cluster (type of completely divided cluster); (2) ventral cluster. G. *A. rotundata*, cross section through skin in region of marginal cluster, showing lateral aspects of nuclear, duplex-spermatozoid and marginal triplex ducts. H. *A. cydoniae*, median marginal triplex cluster (type of undivided cluster). I. *A. rotundata*, terminal aspect of portion of marginal cluster, showing details of the triplex type of cluster.

Figures A, C, E, F and H drawn to the same scale.

Morphology.—Antennae five-segmented; brachia heavily chitinised (the material examined is very heavily chitinised over the entire body surface, the heaviness of chitinisation apparently being caused by disease or exposure or both, so that it is doubtful that the condition observed in the brachia is normal. A single specimen which appears more normal has the brachia weakly chitinised); brachia with a well-marked constriction behind the brachial plates, as in *rotundata* (text-fig. 4, B); brachial plates very similar to those of *gemmifera*, with a broad collar and narrowed crater (text-fig. 4, F); anterior spiracles large, as broad as brachial plate, more or less angular and bearing well over 100 pores; canellae entirely absent; posterior spiracles with 11–12 pores; dorsal spine straight and almost 1.5 times as long as diameter of brachial plate; pygidial apodemes apparently present, but much less conspicuous than in *rotundata*; perivaginal pore clusters saucer-shaped and as broad as width of anal tubercle at fringe; marginal duct clusters almost but not quite divided into

two parts, so that they appear as two adjacent oval clusters connected by a narrow isthmus of ducts (text-fig. 5, E); each half of marginal duct clusters with 3-4 nuclear ducts; anterior marginal ducts in a compact circular cluster of from 35-40 ducts (text-fig. 5, C); median and posterior ventrals similarly shaped and somewhat compactly grouped, of 45-50 and 18-20 ducts respectively; from insufficient evidence to state positively it appears as though there is a well-marked dorsal cluster of medium sized ducts; anal tubercle of an elongate form similar to *rotundata*, but without the median swelling or ring of that species and with the unusually heavily chitinised pre-anal plate well marked off by a distinct suture (text-fig. 3, J). Length 3 mm.

Remarks.—This species is most closely related to *rotundata*, but is easily distinguished therefrom on the basis of numerous characters. From *gemmifera* it likewise differs very markedly, as may be seen by comparing descriptions and figures.

Austrotachardiella gemmifera, Cockerell (Plates xvi, E; xviii, J, Y; and text-figs. 3, K; 4, C).

1893—*Tachardia gemmifera*, Ckll., Can. Ent. xxv, 181.

1893—*Tachardia gemmifera*, Targioni-Tozzetti, Contr. l'étude Gom. laq. 121.

1893—*Tachardia gemmifera*, Targioni-Tozzetti, Ou Species of Lacca. 32.

Type Host and Locality.—Jamaica, Kingston: on *Chrysobalanus icaco*.

Material Examined.—Part of type material. From Cockerell.

Habit.—From Cockerell: "Some months ago Mr. H. Vendryes directed my attention to a Coccid which was damaging a Coco Plum in his garden, and kindly gave me some twigs with many scales upon them. These were evidently referable to a new *Tachardia*, which I call *gemmifera*, on account of the ruby-like prominence on the dorsum of the scale. The female scales . . . are subglobular, shiny, crimson-black, with a crimson ruby-like prominence on the centre of the back, best seen in somewhat immature examples. There are also one or two dorso-lateral prominences, more or less obscure. Sides with 4 or 5 keel-like folds. . . . Length of scale, 5 mill.; diam., 5 mill.; alt., about 4 mill.

"The scales are extremely hard, but will fracture if sufficiently pressed; sides of scale crimson by transmitted light.

"The lac when heated melts to a substance about the colour of guava jelly (?), which turns crimson on the application of caustic soda; this colour-change is most marked." The question mark is mine.

Morphology.—Antennae about five-segmented; brachia weakly chitinised, so that no constriction is visible, even though it might actually be present; brachial plates with broad collar and narrow crater (text-fig. 4, C); anterior spiracles large, about as broad as long, and distinctly broader and plainly larger than brachial plate, bearing from 130-140 pores (Plate xviii, J); canellae absolutely absent; posterior spiracles with 12 or 13 pores; legs represented by a minute knob or tubercle (Plate xviii, Y); dorsal spine very long and slender, 1.6 times as long as breadth of brachial plate and plainly longer than chitinous part of anal tubercle, including fringe (Plate xvi, E); pygidial apodemes apparently absent; perivaginal pore clusters saucer-like, 1.2 times as broad as anal tubercle at fringe; marginal clusters all entirely subdivided into two parts as in *rotundata*, each half with three nuclear ducts; anterior ventral duct cluster loosely annular, of about 55 ducts; median ventrals similar; posterior ventrals of about 30 ducts; with a broad annular band of pores present on dorsum, band irregularly ribbon-like and quite distinct (somewhat as shown in Plate x, C); anal tubercle shaped similarly to *bodkini*, but without the distinct separation of the pre-anal plate (text-fig. 3, K). Length 1.5-2 mm.

Remarks.—Undoubtedly most closely related to *bodkini* and *rotundata*, but nevertheless sharply marked off from these two species by a number of good and prominent characters. There should be no difficulty in recognising any of them.

Group of *A. rubra*, Hempel.

Remarks.—This group is clearly distinguished by the undivided marginal duct clusters; by the presence of canellae; by the somewhat smaller size of the anterior spiracles; and by the narrow craters, which are in no known case as wide as the widest part of the collar. It includes, so far as is known, three species—*rubra*, *cydoniae* and *nigra*.

Austrotarchardiella rubra, Hempel (Plate xvi, o; and text-figs. 3, E; 4, G).

1900—*Tachardia rubra*, Hempel, Rev. Mus. Paul. iv, 411.

1901—*Tachardia rubra*, Hempel, Ann. Mag. Nat. Hist. (7), vii, 121.

Type Host and Locality.—Brazil: São Paulo, Cachoeira and Santa Barbara, on *Cydonia* and *Croton*.

Material Examined.—Part of type material. Received from Green.

Habit.—The following is from Hempel: "Clustered in great numbers on the branches of a *Croton* and on other plants. . . . The lac from different individuals usually fuscous, but does not form large masses. The outside is dull and smooth, with many filaments of white secretion scattered over it. The lac is red-orange colour and brittle only in very old specimens."

Morphology.—Antennae five-segmented; brachia weakly chitinised, ordinarily with no visible constriction behind brachial plate; brachial plates with "narrow" collar and bulging, smoothly ovate crater (text-fig. 4, G); anterior spiracles of moderate size and very distinctly smaller than brachial plate, more or less angulate, as broad as long, massed with more than 100 pores; canellae consisting of a straggling irregular band or line of about 60 star pores; posterior spiracles with 12–15 pores; dorsal spine as long as width of brachial plate; pygidial apodemes present; perivaginal pore clusters not evenly circular, as is usually the case, but instead almost elliptical, irregularly depressed, greatest length almost twice as great as width of anal tubercle at fringe (Plate xvi, o); marginal duct clusters with no trace of median constriction, with 4–5 nuclear ducts in the median and posterior clusters and with three nuclear ducts in each of the anterior clusters; anterior ventral duct clusters, loosely grouped, of 50–55 ducts; median ventrals similar to anteriors; posterior ventrals more compact, of 40–50 ducts; without dorsal ducts; anal tubercle with supra-anal plate typical, with pre-anal plate as broad as long and much larger than supra-anal plate (text-fig. 3, E). Length 2.5–3 mm.

Remarks.—This species is easily separated from *cydoniae* or *nigra* by its much more prominent canellae; by the comparatively stubby dorsal spine, as well as by the shape of the brachial plates and anal tubercle.

Austrotarchardiella nigra, Townsend & Cockerell (text-figs. 3, M; 4, E; 5, A, B).

1898—*Tachardia nigra*, Towns. and Ckll., Jour. N.Y. Ent. Soc. vi, 172.

1903—*Tachardia nigra*, Cockerell, Ann. Mag. Nat. Hist. xi, 165.

Type Host and Locality.—Mexico: State of Vera Cruz, Orizaba, on branches of *Acacia* sp.

Previous Records.—Mexico: Jalisco, Tonila, on "tree with umbrella-like leaves."

Material Examined.—Type material and also part of material recorded from Jalisco, Mexico. All from Cockerell.

Habit.—Verbatim from Cockerell, 1898: "Single specimens show the lac to be disposed in a more or less stellate form covering the body of the female, the stellate shape being due to the similar shape of the body of the female. Usually, however, the specimens are massed together on the branches, being so close to each other that the lac becomes confluent, joining the specimens and presenting the form of irregular elongate globular masses more or less confluent. The lac usually has a

decided blackish surface colour, unlike any hitherto known species of the genus; it varies to dark brown in some cases, however. Average diameter . . . 3-4 mm.; height 2-2.5 mm."

Morphology.—Antennae six-segmented; brachia lightly chitinated; brachial plates almost subquadrate, craters not evenly outlined as in *cydoniae* or *rubra* (text-fig. 4, E); anterior spiracles small, longer than broad, no larger than brachial plate, bearing from 45-50 pores; rudimentary canellae present, consisting of 6-7 star pores on either side and caudad of mouth parts; posterior spiracles with 6-7 pores; legs represented by minute chitinous points; dorsal spine very long and slender, 1.8 times as long as width of brachial plate; pygidial apodemes perhaps weakly present; perivaginal pore clusters but little greater in diameter than breadth of anal tubercle at fringe; marginal duct clusters entire, the posterior pair occasionally showing slight traces of a median constriction, with four nuclear ducts (text-fig. 5, A); anterior ventral duct cluster consisting of about 40 ducts grouped into a loosely annular cluster (text-fig. 5, A₂); median ventrals of 22-25 loosely clustered ducts; posterior ventrals of about 30 ducts grouped rather loosely; no dorsal ducts apparently; anal tubercle narrow and rather elongate, the pre-anal plate subequal to the supra-anal plate (text-fig. 3, M). Length 2.5-3.5 mm.

Remarks.—Most closely related to *cydoniae*, although showing some resemblances to *rubra*. The characters are sufficiently distinct to give no excuse for confusion.

Austrotachardiella cydoniae, Hempel (Plates xi, L; xviii, w; and text-figs. 3, I; 4, A, D; 5, D, H).

1900—*Tachardia cydoniae*, Hempel, Rev. Mus. Paul. iv, 410.

1900—*Tachardia rosae*, Hempel, Rev. Mus. Paul. iv, 414.

1901—*Tachardia cydoniae*, Hempel, Ann. Mag. Nat. Hist. (7), vii, 120.

1901—*Tachardia rosae*, Hempel, Ann. Mag. Nat. Hist. (7), vii, 123.

1904—*Tachardia caerulea*, Hempel, Bol. Agr. São Paulo. v, 314.

Type Host and Locality.—Brazil: São Paulo, on cultivated quince (*Cydonia*).

Other Records.—Recorded as *T. caerulea* from Rio de Janeiro, on unknown host; as *T. rosae* from São Paulo, on cultivated roses.

Material Examined.—One slide of type material, received through the courtesy of H. Morrison, of the U.S. National Museum. Two slides labelled as *T. rosae* from P. Vayssière, of France (probably type material), and one slide of *T. caerulea* from Green, also probably type material.

Habit.—Massed on twigs. Lac a very dark colour; lobation lost or indistinct. Hempel gives the following description: "Female test elongate, deep orange-red in colour, with a hump on the dorsum and three processes on each side radiating from the lateral margins, giving it a star-shaped appearance. . . . Many of the individuals are distinct, with soft plastic lac, but in the older specimens the lac is hard and brittle and usually fused into larger masses."

Morphology.—Antennae 5-6 segmented; brachia weakly chitinated; brachial plates small, subovate, crater smoothly rounded (text-fig. 4, A, D); anterior spiracles small, but little longer than broad, about same size as brachial plate and bearing about 50 pores; canellae represented by a straggling line of 15 or 16 pores; posterior spiracles with 2-4 pores; legs represented by tiny chitinous points (Plate xviii, w); dorsal spine slender, 1.8 times as long as diameter of brachial plate; pygidial apodemes apparently weakly present; perivaginal pore clusters small for this subgenus, being distinctly less in diameter than width of anal tubercle at fringe; marginal duct clusters undivided, ovate, with but two or occasionally three nuclear ducts (text-fig. 5, H); anterior ventral duct cluster with 16-18 ducts; median ventrals closely grouped, of 14-15 ducts; posterior ventrals in a circular cluster, of 14-15 ducts; apparently no dorsal ducts present; anal tubercle fairly short, pre-anal plate inconspicuous, supra-anal plate shorter than fringe (text-fig. 3, I). Length 2.5 mm.

Remarks.—Most closely related to *nigra*, but nevertheless very easily distinguished therefrom. It is remarkable for the extreme reduction in size of all the chitinous structures as compared with the size of the insect, a feature that must be seen to be appreciated.

There is scarcely the slightest doubt but that *rosae* and *caerulea* are entirely synonymous with *cydoniae*. I have used the greatest care in comparing material of all three, and I am convinced that Hempel has confused the same insect under three different names.

Unexamined and Doubtful Species.

***Tachardiella cordaliae*, Leonardi.**

1911—*Tachardia cordaliae*, Leon., Bol. Lab. Zool. Sc. Sup. Agr. Portici. v, 258, fig. *Type Host and Locality.*—"Argentina," on *Cordalia lineata*.

Remarks.—Unfortunately neither material nor the description of this species has been available to me and hence I can form no opinion concerning it. Morrison regards it as probably synonymous with *Tachardiella lycii*. (See under "Remarks" on that species, where I quote Morrison in full.)

***Tachardiella artocarp*, Hempel.**

1921—*Tachardia artocarp*, Hempel, Arch. Escola Sup. Agr. e Med. Vet. Nictheroy, v, no. 1-2, 143-146, 1 plate.

Records.—"Brazil," from jak (*Artocarpus*), cashew (*Anacardium occidentale*) and *Terminalia catappa*.

Remarks.—Neither material nor the description of this species has been available to me.

***Tachardiella argentina*, Dominguez.**

1906—*Tachardia argentina*, Domin. (sine descr.), An. Soc. Cient. Argentina. 219, fig. (?)

1907—*Tachardia argentina*, Domin. (sine descr.), Bol. Min. Agr. vii, 3, 148 and 150.

Records.—"Argentina," on *Acacia cavenia*.

Remarks.—This is a nomen nudum and has no nomenclatural standing since no valid description of the species has apparently been published. According to Sanders' catalogue, there is a figure published in connection with the first mention of the species, and it is possible that this figure will render the name valid.

Suprageneric Group of Austrotachardia.

(*Deep crater group.*)

Characterised by the absence of perivaginal pore clusters in adult females; by very deeply invaginated craters; by dorsal spine ducts of a non-dendritic type, bearing apparently 5 or $5\frac{1}{2}$ pairs of marginal duct clusters.

Includes only the peculiar new genus *Austrotachardia*.

Austrotachardia, gen. n.

(Plates x, c; xi (part); xix; and text-figs. 1 and 2).

Orthotype.—*Tachardia angulata*, Frogg. Australia: New South Wales.

Diagnosis.—Antennae of small type; crater extremely deep and narrow; dorsal spine ducts non-dendritic; with no perivaginal pore clusters; with $5\frac{1}{2}$ pairs (11) marginal and ventral duct clusters.

Morphology.—Antennae usually very small, segmentation obscure or even absent; brachia moderately short to long, often heavily chitinated throughout; brachial plate deeply invaginated into a long narrow crater, which is bordered by a specifically variable fringe composed of alternate acute chitinous projections and setae; anterior

spiracles usually fairly large and more or less "usual" in appearance; posterior spiracles normal; dorsal spine always present, not borne upon a fleshy pedicel, as is usually the case in *Tachardia* and *Tachardiella*; dorsal spine ducts non-dendritic (Plate xix, L, M); never a trace of perivaginal pore clusters; marginal duct clusters duplex, either 10 or 11 in number, usually with three anterior to the brachia and four pairs posterior to the brachia. Apparently the anterior pair have fused to form a single median cluster, while the remainder of the clusters have maintained their individuality. Ventral duct clusters usually present in the same number as the marginals (see *acaciae*). Anal tubercle small or large; pre-anal plate present or absent; anal fringe usually consisting of two fairly long ligulate lobes on either side of the median cleft and with other smaller lobes distad of these (Plate xix, A, C); anal ring setae usually projecting far beyond the anal fringe (Plate xix, A, C), but in *acaciae*, where the anal tubercle is very large and heavy, the anal ring is apparently retracted considerably under the supra-anal plate, so that the setae appear small and weak and do not project as far beyond the fringe (see under *acaciae*, p. 198); anal ring apparently quadrately sectoried.

Remarks.—In some respects, as in the absence of the perivaginal pore clusters, this genus seems to approach *Tachardina*, but the presence of numerous other and more fundamental characters that link it with the *Tachardiella-Tachardia* groups seem to show that this seeming resemblance is no more than a parallelism. However, it differs so strongly in some other features that I personally regard it as of a rank equivalent to both of these genera combined (text-fig. 2).

In speculating as to its derivation it appears to me that the facts in the case can be best explained on the hypothesis that it is an offshoot of an early *Tachardiella*-like stem, a divergence in all probability far earlier than the *Tachardia* departure. The way in which it reached its present habitat, Australia, from its hypothetical place of origin, America, is a difficult question to answer. Personally it seems to me that a southern route of migration is the most logical hypothesis in this case, and hence it may have reached Australia via the old land connection through Antarctica.

The species may be separated by means of the following key:—

1. With distinctly visible pre-anal plate; dorsal spine ducts as long again as spine itself (Plate xix, L) 2
 With no pre-anal plate; dorsal spine ducts no longer than spine itself (Plate xix, M) 3
2. Brachia long slender tubes (Plate xix, N) *australis*, Frogg. p. 195
 Brachia not slender and tube-like, more or less basally flaring (Plate xix, B) *melaleuca*, Mask. p. 196
3. Anal tubercle at least as large as brachium; canellae fairly well developed *acaciae*, Mask. p. 198
 Anal tubercle considerably smaller than (scarcely more than half) brachium; canellae almost if not quite absent *angulata*, Frogg. p. 197

Group of *A. melaleuca*, Mask.

Remarks.—This group is defined by the slender dorsal spine with its elongate ducts (Plate xix, L) and by the presence of a well-marked pre-anal plate. It includes *australis* and *melaleuca*.

Austrotachardia australis, Froggatt (Plates xi, Q; xix, E, N, R).

1899—*Tachardia australis*, Froggatt, Agr. Gaz. N.S. Wales. x, 1160.

Type Host and Locality.—Australia: Queensland, on *Beyeria viscosa*.

Material Examined.—A lot of material, determined by Froggatt, from Queensland, on unknown host. Received from Green.

Habit.—Test of clear reddish lac somewhat resembling that of *Tachardia lacca*, externally smooth and gently lobed. On material available the tests are massed on the twigs to a depth of 3–4.5 mm. This is apparently a “true” lac, such as is found generally in *Tachardia* and *Tachardiella*.

Morphology.—Antennae small, two-segmented (Plate xix, E); brachia long and slender, bearing a narrowly and deeply invaginated crater with internally a small “bracket-like” appendage suggesting a similar but external structure found in *acaciae* and *melaleuca* (Plate xix, N); no trace of canellae; anterior spiracles almost as broad as long and somewhat more angulate than usual (Plate xix, R); dorsal spine broken or distorted in all available specimens, but of the type of structure found in *melaleuca*; marginal duct clusters as in *melaleuca* but with three nuclear ducts; ventral clusters composed of about 30 ducts each; there is present between the anterior spiracles and the mouth parts a small cluster of 4–5 ducts that apparently has no connection with the marginal or ventral clusters; no dorsal ducts present; anal tubercle conspicuous on account of the large pre-anal plate (larger than supra-anal plate), which is fairly heavily chitinised; anal fringe somewhat similar to that of *melaleuca*, but it could not be definitely worked out. Length 4–4.5 mm.

Remarks.—With the material available it was impossible thoroughly to work out the marginal and ventral duct clusters, but they are almost surely very similar in number and structure to those of *melaleuca*. It may be distinguished at a glance by the narrowly elongate brachia.

***Austrotachardia melaleuca*, Maskell (Plate xix, A, B, D, K, L, T, X, Y).**

1891—*Carteria melaleuca*, Mask., Trans. N.Z. Inst. xxiv, 54.

1894—*Tachardia melaleuca*, Maskell, Trans. N.Z. Inst. xxvii, 31.

1899—*Tachardia melaleuca*, Fuller, Trans. Ent. Soc. Lond. 457.

Type Host and Locality.—Australia: New South Wales, on *Melaleuca uncinata*. These are not certain. Maskell designated no particular host plant nor locality, so the first listed in each case was here adopted as fixing the type.

Other Records.—I quote Maskell verbatim: “*Hab.* In Australia, on *Melaleuca uncinata* and *Eucalyptus* sp. (sent in by Mr. French), and on *Melaleuca pustulata* and *Aster axillaris* (sent in by the late Mr. Crawford).” In 1894, Maskell gave as an additional host *Leptospermum laevigatum*, and gave as the species range “New South Wales and Victoria.” Fuller records it from Perth, Western Australia, on *Kunzia* or *Melaleuca*.

Material Examined.—New South Wales, Castle Hill, on an unknown host. Determination by Froggatt. Material from Green.

Habit.—Lac dark red to purplish; surface of test smooth. Isolated individuals have the test rather elongate and beset with two pairs of symmetrical lobes. In crowded conditions the tests fuse, and this characteristic lobation is lost. Length 4.5 mm., width 2 mm., height 2 mm. Maskell states that the lac is readily soluble in alcohol, a fact that indicates that it is in the nature of a true lac.

Morphology.—Antennae very small, single-segmented (Plate xix, D); brachia comparatively short and, as in *angulata*, with a chitinous process or “bracket,” which seems to be somewhat narrower and less conspicuous than in that species, and, as in that species, is situated near an emargination in the crater rim (Plate xix, B, bracket as seen laterally); there is a small inner lobe to the crater, which may or may not be visible, depending upon the position of the brachium; anterior spiracles comparatively small and with but few pores (Plate xix, T); canellae very small and difficult to observe, consisting of an irregular line of 6–10 star pores; posterior spiracles as in *acaciae*, situated in a scattered cluster of star pores (Plate xix, Y) (see *Tachardiella glomerella* and *baccharidis*); dorsal spine slender and small, ducts terminated by small pyriform enlargements or nodes (Plate xix, L); marginal duct clusters small, subcircular, distinctly duplex, with but two or at most three nuclear

ducts (Plate xix, k); ventral duct clusters all present and consisting in all cases of a fairly compact group of 12-13 ducts; adjacent to the mouth parts is a small anomalous cluster of four or five ducts which, as in *australis*, is apparently not connected with either the ventral or dorsal duct clusters; no dorsal duct cluster; pre-anal plate less distinct than in *australis* but definitely present as a chitinous patch, smaller than the supra-anal plate; anal fringe typical (Plate xix, A). Length 2.2 mm.

Remarks.—The brachia of this species and of *angulata* are somewhat similar, but other more fundamental characters place them definitely apart. Judging from Fuller's description of *A. convexa*, his record of *melaleuca* is of doubtful import, to say the least.

Group of *A. angulata*, Froggatt.

Remarks.—Anal spine stouter than in the group of *A. melaleuca* and with numerous ducts literally filling the conical spine and terminating almost flush with its base (Plate xix, I, M); with pre-anal plate absent or at most but faintly indicated by slight traces of heavier chitinisation anterior to the supra-anal plate. It includes only *angulata* and *acaciae*.

***Austrotachardia angulata*, Froggatt (Plates x, C; xi, S; xix, C, F, G, J, M, P, S, U, W).**

1911—*Tachardia angulata*, Froggatt, Proc. Linn. Soc. N.S. Wales. 36-154.

Type Host and Locality.—Australia: New South Wales, Eden, on quince trees.

Other Records.—In original description also recorded from Milton, New South Wales, on quince trees.

Material Examined.—Although not so labelled, probably a part of the type material. Labelled: "Quince tree, Eden, N.S.W." Also some specimens from an unknown host in the same region. Specimens identified by Froggatt. From Green.

Habit.—Verbatim from Froggatt: "Wax test enclosing female dark red to black in colour, broad and rounded at the base, coming to a blunt point at the apex, when viewed from above it is seen to be fluted, with four distinct ridges meeting at the summit. Outer surface smooth. . . . In general appearance resembling a large blunt rose-thorn; sometimes solitary, at other times in groups of three or four, in contact at the base." Height 6-7 mm., basal diameter 5-6 mm.

Morphology.—Antennae apparently single-segmented (Plate xix, F); brachia comparatively short, in the form of a broad and basally flaring collar, longer on one side than the other and with a comparatively narrow longitudinal strip of distinct, although small, pores (Plates x, C; xix, G); anterior spiracles large, somewhat elliptical and with numerous pores (Plate xix, S); no trace of canellae; posterior spiracles somewhat larger than usual and with more numerous pores; posterior two pairs of legs observed as chitinous points near the posterior spiracles; anal spine extremely large and literally massed full of short ducts (almost as great in area as entire anal tubercle) (Plate xix, M); marginal duct clusters duplex, with 7-8 nuclear ducts (Plate xix, J); ventral duct clusters well developed, those anterior to the brachia consisting of from 50-55 ducts; those posterior to the brachia of 35-40 ducts; with, as in the preceding two species, a small cluster of 6-7 ducts near the mouth parts; with a remarkable, roughly annular, band of prominent dorsal ducts, which roughly outline a crude shield-shaped area (Plate x, C); supra-anal plate small, broader than long and characteristically rugose, with no pre-anal plate (Plate xix, C); anal fringe typical (Plate xix, C). Length 3 mm.

Remarks.—A very distinctive species. Apparently it is most nearly related to *acaciae*, but is nevertheless widely divergent in several respects, such as in lacking canellae and in possessing the remarkable dorsal duct cluster above described.

Austrotachardia acaciae, Maskell (Plates xi, r, ff; xix, h, i, o, q, v).

1891—*Carteria acaciae*, Maskell, Trans. N.Z. Inst. xxiv, 56; xii.

1893—*Tachardia acaciae*, Targioni-Tozzetti, On Species of Lacca. 31.

Type Host and Locality.—I quote Maskell: "In Australia, from *Acacia* sp. My specimens were sent in by Mr. J. G. O. Pepper, of Adelaide, with a note: 'Collected by Mr. J. G. O. Helms, of the Elder Exploration, in central Australia.'" The Fernald Catalogue erroneously lists the host of this species as *Acacia greggii*, which is an American *Acacia*. The mistake was due, undoubtedly, to misinterpreting a statement of Maskell's, where he compares *acaciae* with *Tachardiella larreae*, which "also occurs on *Acacia greggii*." Maskell, no doubt, meant that *larreae* occurred also on an *Acacia*.

Material Examined.—Australia: New South Wales, on *Acacia doratoxylon* and *Hakea* sp. Material from Green. This determination is somewhat doubtful, but the specimens at hand agree sufficiently well with Maskell's original description to make it probable that they are identical.

Habit.—I quote Maskell: "Insects excreting a quantity of light red or pinkish resinous matter, aggregated in masses or detached in irregular pieces."

Morphology.—Antennae minute, two-segmented, tipped by 2-3 long setae; brachia somewhat narrowly subconical, widest basally, truncate at tip and partially surrounded by, or rather bearing on one side a terminally rugose, level, bracket-like shelf or rim, which is attached very much as is the ordinary "bracket fungus" to a tree trunk (Plate xix, h); this process is borne on the side of the brachium, where there is an emargination in the crater rim as shown in Plate xix, h; crater itself deep and conical, the tip of the depression projecting distinctly past the basal part of the brachial appendage; anterior spiracles more or less firmly attached or fused to the basal portion of the brachia, with comparatively few pores (Plate xix, h); canellae present, consisting of a distinct band of 25-30 star pores (a portion is shown in Plate xix, h); posterior spiracles situated but little behind anterior spiracles, well developed and in the midst of a distinct cluster of scattered star pores (see *Tachardiella glomerella* and *baccharidis*); dorsal spine of the same type as in *angulata*, but much slenderer and with much fewer ducts (Plate xix, i); marginal duct clusters all distinctly present, the ducts themselves somewhat short and flaring; all marginal clusters of the duplex type, the nuclear ducts scarcely fewer than the duplex ducts (Plate xix, q); Plate xix, o, shows the beet-like internal termination of the duplex ducts in this species; no traces of ventral duct clusters found; no dorsal ducts; supra-anal plate large and elongate, apparently being a little larger than a brachium; material insufficient to permit working out anal fringe, but apparently the anal ring is retracted far under a heavy chitinous projection entirely different in character from the typical fringe; anal ring and anal ring setae apparently small and rather weakly developed. Length 3 mm.

Remarks.—This widely divergent species is apparently related to *angulata* by the type of dorsal spine, but there the resemblance ends. The anal tubercle of this species requires more careful study to determine whether or not there is a truly essential difference between it and the type found in the other species of the genus. The canellae are unusually well developed, while the apparently total absence of ventral duct clusters furnishes another anomalous feature. Specimens show an extreme abundance of the peculiar spermatozoid ducts, which do not show in other species, but this may be due to accidents of preparation breaking them off in the other material. They should be present.

Doubtful Species.

Austrotachardia (?) convexa, Fuller.

1899—*Tachardia convexa*, Fuller, Trans. Ent. Soc. Lond. 457.

Type Host and Locality.—Western Australia: Swan River, on *Hypocalymma* sp.

Description.—I quote all of value in Fuller's original description :—

"Test of female dark brown, very convex, smooth. . . . Length 0.15 inch. Adult female elongate, thoracic tubes conspicuous. Abdomen prolonged, with a chitinous ring at the apex. . . . Antennae small, atrophied, not jointed. . . . Anterior spiracle larger than posterior and surrounded by groups of small pores. Dorsal spine conspicuous, with several adjacent hairs."

Remarks.—This species is almost surely an *Austrotachardia*, judging on the basis of the "elongate, conspicuous thoracic tubes" and the vestigial antennae. Apparently the "adjacent hairs" to the dorsal spine are the ducts of the spine, in which case the species will fall in the group of *A. melaleuca*.

Tachardinini, tribus n.

(Short-duct group.)

This large group is characterised by the possession of a peculiar type of tubular duct, which is short, rarely longer than broad, and with a terminal loculus of an entirely different type from that found in Tachardiini (the structure of these ducts are shown in text-fig. 8, A₁, A₂, A₃, A₄, A₅, D₁, D₂, E₁, E₂); by canellar pores which possess a median spinous process (text-fig. 6, F, G, H); by the almost invariable presence of pseudospines on the brachial plates (Plate xx, A to M); and by having more than six pairs of marginal duct clusters (Plate x, B).

This group includes only the genus *Tachardina*.

Tachardina, Cockerell.

(Plates x, B; xi (part); xx; and text-figs. 1, 2, 6, 7, 8).

1901—*Tachardina*, Cockerell, The Entom. xxxiv, 249.

1920—*Tachardia*, Brain, Bull. Ent. Res. x, 122.

1921—*Tachardina*, MacGillivray, The Coccidae. 154.

Orthotype.—*Tachardina albida*, Ckll. Natal, South Africa.

Diagnosis.—The characterisation given above for this group sufficiently diagnoses the genus. Perivaginal pore clusters are never present.

Morphology.—Antennae as a rule well developed, somewhat as in *Tachardiella*; brachia short to long, nearly always membranous and difficult to see in a cleared mount; brachial plate large to small, usually ovate, circular or most often subtriangular; surface of brachial plate usually nearly level, but often with a shallow depression, as in *aurantiaca* (Plate xx, i); brachial plate usually beset with pseudospines of the structure shown in Plate xx, D, although these may apparently be modified so as to appear as in Plate xx, S; occasionally they are apparently even replaced by true setae, as in *T. affluens* (Plate xx, B); anterior spiracles usually of a simple ovate type, never so greatly developed as in *Tachardia* or *Tachardiella*; canellae usually present, but never very strongly developed, usually consisting of a short band of star pores not more than twice the length of the spiracle itself; posterior spiracles small, often set in the midst of a loose cluster of star pores; legs present in a few species, in all cases consisting of very minute vestiges; dorsal spine usually broadly conical, rarely set upon a fleshy pedicel; dorsal spine ducts of a typical dendritic type (Plate xx, Q, N); apparently the dorsal spine is absent in one species, *T. albida*, but there is here a possibility that careful observation will show it to be actually present, but so loosely attached as to be commonly lost in the processes of preparing specimens for study; marginal duct clusters numbering apparently from 14–18 (7–9 pairs), which are circular or ovate, ducts as a rule very compactly grouped; marginal clusters occasionally of a peculiar duplex type, such as is shown in text-fig. 8, H or N; ventral duct clusters probably always present, but as a rule very weakly developed, usually consisting of about three pairs of loosely grouped, minute ducts; no dorsal ducts observed; anal tubercle assuming various forms, but generally fairly short, being rarely longer than broad and often with a

very convex lateral profile (text-fig. 7, A, c); anal fringe usually consisting of long ligulate lobes, but often very divergent from this type; anal ring either entire or quadrately sectoried.

Remarks.—In spite of the general homogeneity of this genus, there is a wide range of variation in certain of its features, and consequently it is found to break up into a number of more or less well-marked groups and subgenera. However, the number of species so far known is too few to permit the arrangement of the subdivisions in really satisfactory form, and until more collecting is done the arrangement here given must be regarded as more or less provisional.

In line with the general morphological isolation of the genus, it is interesting to note its isolation in regard to the type of "lac" secretion. This point is fully discussed in the introduction.

Speculation as to the origin and derivation of this group is still more uncertain than when applied to any of the preceding genera, but it seems to me that there is no question that the split between the long duct group, typified by *Tachardiella*, and the present genus occurred very early in the history of the subfamily and is correspondingly fundamental in its character. Assuming America as the centre of dispersal, then it seems most probable to me that *Tachardina* reached its present

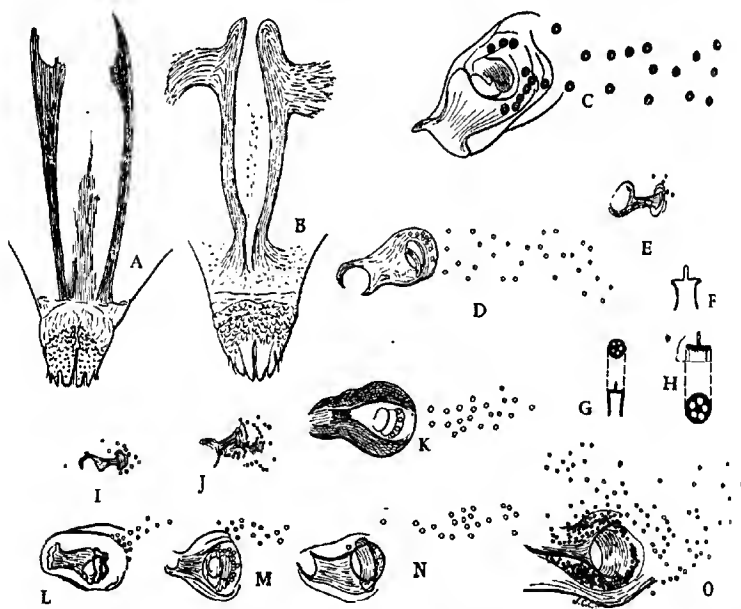


Fig. 6. *Tachardina* and *Afrotachardina*. A. *T. ternata*, dorsal aspect of anal tubercle, showing internal apodemes and supra-anal plate. B. *T. actinella*, dorsal aspect of anal tubercle, showing internal apodemes and supra-anal plate. C. *T. ternata*, anterior spiracle and canella. D. *T. actinella*, anterior spiracle and canella. E. *T. actinella*, posterior spiracle. F. *T. ternata*, lateral aspect of canella pore, showing central process. G. *A. brachysetosa*, lateral and terminal aspects of canella pore. H. *T. albida*, lateral and terminal aspects of canella pore. I. *T. lobata*, posterior spiracle. J. *T. albida*, posterior spiracle. K. *A. brachysetosa*, anterior spiracle and canella. L. *T. lobata*, anterior spiracle and canella. M. *T. theae*, anterior spiracle and canella. N. *T. decorella*, anterior spiracle and canella. O. *T. albida*, anterior spiracle and surrounding pore area or "canella."

(All figures of similar parts to the same scale, excepting c.)

habitat in Africa and Asia eastward across the old land connection between Africa and the West Indies (Gondwana). Of course there is no fundamental objection to assuming Africa as the centre of dispersal of the entire subfamily, but taking everything into consideration, it appears to me that all the facts in the case are more easily satisfied if we assume an American origin for the group.

The two named subgenera may be separated by means of the following key:—

1. Marginal duct clusters with two closely associated smaller clusters of smaller ducts (text-fig. 8, A, D); anal fringe not of the usual ligulate type ..

Afrotachardina subgenus n. p. 201

Marginal duct clusters without such auxiliary clusters, of the type shown in text-fig. 8, B, etc.; anal fringe of the ligulate type shown in text-fig. 7, B, D, etc. *Tachardina*, Cockerell. p. 204

***Afrotachardina*, subgen. n.**

(Plates xi (part); xx; and text-figs. 1, 2, 6, 7, 8).

Orthotype.—*Tachardia longisetosa*, Newstead. Uganda.

Diagnosis.—Marginal duct clusters with two closely associated auxiliary duct clusters; anal fringe widely divergent from the typical ligulate type found in *Tachardina*; median loculus of marginal ducts much reduced, appearing as an irregular slit.

Remarks.—There is some difficulty in defining this subgenus in spite of its wide divergence from typical *Tachardina*, this arising in large part because of the wide differences in certain characters, which appear to me as rather fundamental, within the subgenus itself. It may be that when the African fauna is more thoroughly known, both of the species recognised as falling in this group will be found to indicate two distinct groups, or, on the other hand, it might prove that I am wrong in ranking them as being so distinct as I here do. However, the structure of the anal tubercle, particularly in reference to the anal fringe, has so proved its worth in the other genera of this subfamily that I am personally convinced that it has at least more than a superficial meaning in the present case. These differences are taken up in detail under the respective species, which may be separated by means of the following key:—

Anal fringe short (probably vestigial); anal ring setae stout and extending far beyond tip of anal tubercle or "fringe" *longisetosa*, Newst. p. 201

Anal fringe much retracted medially; anal ring setae short and weakly developed, extending but little beyond anal tubercle or fringe

brachysetosa, sp. n. p. 230

***Afrotachardina longisetosa*, Newstead (Plate xx, A; text-figs. 7, A; 8, A).**

1911—*Tachardia longisetosa*, Newstead, Bull. Ent. Res. ii, 102.

Type Host and Locality.—Africa: Uganda, Entebbe, on *Ficus* sp. (bark-cloth tree).

Material Examined.—Part of the type material. From Green.

Habit.—Verbatim from Newstead: "Test of adult female smoky ochreous buff to dusky amber-yellow. Isolated examples are distinctly hemispherical in form, with strong and somewhat wavy ridges radiating from dorsum. Central orifice distinct and surrounded by a dull crimson area. Diameter 3.5 mm."

Morphology.—Antennae of the typical long type; brachia long and slender; brachial plate triangular, with a more or less elliptical, shallow crater present, which is thickly beset with typical pseudospines (Plate xx, A); brachial plates much "thinner" than in *brachysetosa*, i.e., there is no heavy chitinous structure projecting down the brachium as in that species; anterior spiracles typical in shape, with few pores, as long as basal width of brachial plate; canellae not observed; posterior spiracles typical; dorsal spine not observed; marginal duct clusters 16, distinctly and

narrowly ovate, the length being almost twice the width, rather large, being subequal in size with the brachial plates (text-fig. 8, A); typically on either side of the marginal clusters there is a small independent cluster of auxiliary ducts, which differ from the marginal ducts in showing the characteristic shape of the median loculus (compare text-fig. 8, A_4 with E_2); the marginal ducts apparently characterised by a larger number of marginal loculi than is usually the case, up to five being ordinary; there is apparently a small dorsal cluster of the same type of ducts as in the auxiliary

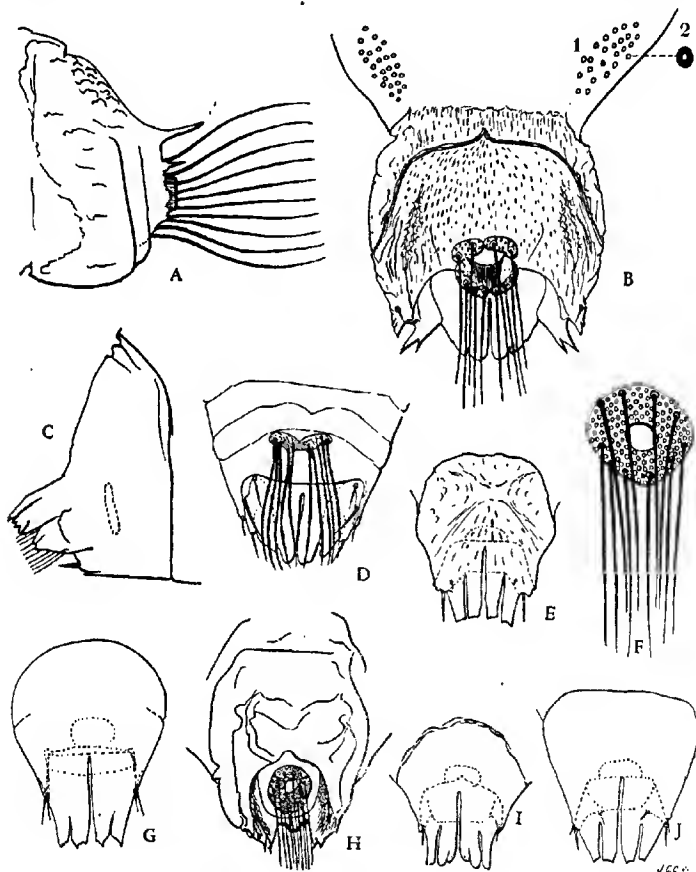


Fig. 7. *Tachardina* and *Afrotachardina*. A. *A. longisetosa*, lateral aspect of anal tubercle, showing the greatly reduced anal fringe and correspondingly great development of the anal ring setae. B. *T. albida*, ventral aspect of anal tubercle, showing the fringe, the quadrately lobed anal ring, the ventral aspect of the anal fringe, and the inner aspect of the supra-anal plate; (1) tubercle pore cluster; (2) terminal aspect of individual pore. C. *T. lobata*, lateral aspect of anal tubercle. D. *T. acinella*, ventral aspect of anal fringe and supra-anal plate. E. *T. decorella*, dorsal aspect of supra-anal plate and fringe. F. *T. decorella*, anal ring and setae, illustrating the unsegmented type of anal ring. G. *T. lobata*, dorsal aspect of supra-anal plate and fringe. H. *A. brachysetosa*, ventral aspect of anal tubercle showing the peculiarly retracted type of anal fringe, continuous anal ring and weakly developed anal ring setae. I and J. *T. theae*, supra-anal plate and anal fringe: I from India, J from Formosa.

(Figures not necessarily drawn to the same scale.)

marginals; no ventral ducts apparently; anal tubercle short, chitinised at tip; apparently the median cleft typical of the subfamily is absent, and in fact the anal fringe appears to be reduced to about four widely separated spinose processes, between which the chitinous margin of the anal tubercle appears irregularly serrate; anal tubercle rising rather abruptly as seen from a lateral aspect (text-fig. 7, A); anal ring superficially appearing 10-lobed, but closer examination seems to show that this is a "scalloping" effect rather than true segmentation, and hence it is essentially entire; anal ring setae very stout, spreading and extending far beyond anal fringe or rather tubercle (text-fig. 7, A). Length about 4 mm.

Afrotachardina brachysetos, sp. n. (Plates xi, DD; xx, H, G, N; and text-figs. 6, G, K; 7, H; 8, D).

Type Host and Locality.—Africa: Uganda, Entebbe, on *Anona muricata*. Material from Green.

Habit.—Isolated or massed on twigs; isolated specimens showing alternating radial furrows and ridges; test 2.5 mm. high, and when massed, lac is smooth surfaced and gently lobed. Lac surface a somewhat "dirty" light yellowish orange; secretion when broken showing a clear, transparent, amber-like fracture; walls of test about $\frac{1}{2}$ mm. thick and gutta-percha like.

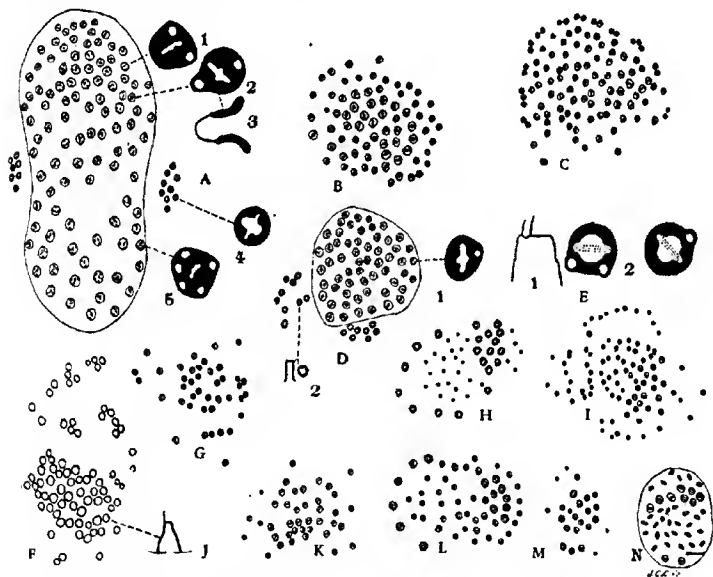


Fig. 8. *Tachardina* and *Afrotachardina*. A. *A. longisetosa*, marginal duct cluster; (1), (2) and (5) terminal aspects of individual ducts, showing locular variations; (3) lateral aspect of marginal duct; (4) terminal aspect of one of the smaller "accessory" ducts. B. *T. theae*, marginal duct cluster. C. *T. actinella*, marginal duct cluster. D. *A. brachysetos*, marginal duct cluster; (1) terminal aspect of individual duct; (2) details of one of smaller "accessory" ducts. E. *T. theae*, details of structure of marginal ducts; (1) lateral aspect; (2) terminal aspect. F. *T. albida*, marginal duct cluster. G. *T. aurantiaca*, marginal duct cluster. H. *T. ternata*, marginal duct cluster. I. *T. decorella*, marginal duct cluster. J. *T. albida*, lateral aspect of individual marginal duct. K. *T. affluens*, marginal duct cluster. L. *T. lobata*, one of posterior elongate marginal duct clusters. M. *T. lobata*, small marginal duct cluster type (found adjacent to spiracles and anal tubercle). N. *T. mimda*, marginal duct cluster (after Morrison).

(All figures, excepting N, upon the same scale of magnification.)

Morphology.—Antennae not observed; brachia of moderate length (Plate xx, H); brachial plate when observed terminally similar to that of *longisetosa* but much smaller, being scarcely half as large; with crater much as in *longisetosa* (Plate xx, G); the brachial plate differs fundamentally by the great thickness of chitin, which is so thick, as a rule, as to prevent a terminal aspect of the crater from being obtainable in a slide mount (Plate xx, H); anterior spiracles as large as brachial plate, rim unusually heavily chitinised, with very few pores (text-fig. 6, K); canellae of a few star pores scattered over an area somewhat less than that of spiracle itself (text-fig. 6, K); posterior spiracles as usual; dorsal spine borne upon a more or less distinct pedicel, of the usual shape; the ducts are somewhat less branched than usual (Plate xx, N); marginal duct clusters about 16, more or less circular in outline (text-fig. 8, D); the cluster immediately anterior to anterior spiracles smaller than the rest; with two closely associated marginal auxiliary clusters of a different type of duct, as in *longisetosa* (text-fig. 8, D); ventral duct clusters apparently present as loose clusters of small tubular ducts; apparently with a small loosely grouped cluster of small ducts on the dorsum; profile of anal tubercle much as in *longisetosa*; anal fringe very peculiar, apparently without the typical median cleft; apparently the median lobes have fused and been greatly reduced, while the lateral lobes have at least remained the same size (text-fig. 7, H); anal ring entire, no traces of lobation or scalloping, very broad, being considerably wider than diameter of anal opening (text-fig. 7, H); anal ring setae weakly developed, slender and short, not projecting far beyond outer lobes of anal fringe. Length 2.5–3 mm.

Remarks.—It is of little value to compare a form as widely divergent as this with even its closest relative, but there are a number of very noteworthy features that clearly set it off by itself, such as the reversion of the spiracles (one of the two species outside of *Tachardina* where this occurs) and the peculiar anal fringe and brachial plate. It will be very interesting to find whether new species will fill in the large gaps between this species and *longisetosa*, and between both and *Tachardina*, or whether they will, as I personally think probable, separate into a number of well-defined groups defined largely on such characters as those above enumerated.

Tachardina, Cockerell, subgenus typicus.

(Plates x, B; xi (part); xx; and text-figs. 1, 2, 6, 7, 8).

Orthotype.—*Tachardina albida*, Ckll. Natal, South Africa.

Diagnosis.—Marginal duct clusters without adjacent auxiliary clusters; anal fringe consisting of more or less elongate, ligulate lobes; median loculus of marginal ducts of shape shown in text-fig. 8, E₂.

Remarks.—This subgenus is most easily recognised from the anal tubercle, and should be easily distinguished from *Afrotachardina* on this basis alone. It includes a couple of rather well-marked groups, which are characterised in their proper systematic position. The species may be separated by means of the following key:—

1. With a pair of prominent, elongate, longitudinal, internal chitinous processes or apodemes in the pygidial region 2
Without such structures or apodemes 3
2. Brachial plates subovate and subequal in length to the dorsal spine; from India *ternata*, sp. n. p. 208
Brachial plates subtriangular and almost 1.4 times as long as dorsal spine; from Natal *actinella*, Ckll. & King. p. 207
3. Brachial plates with two distinct dimples or depressions, the pseudospines being thus separated into two distinct clusters . . . *aurantiaca*, Ckll. p. 205
Brachial plates almost or quite level; no trace of depressions or division of pseudospines into more than a single cluster 4
4. Anal ring distinctly divided into four segments or sectors 5
Anal ring entire, being continuous and unsegmented 6

5. Anal fringe consisting of a broad medio-distally incised lobe, lying on either side of the median cleft, and then a spinose process (text-fig. 7, B) *albida*, Ckll. p. 206
Anal fringe consisting of a pair of truncate, ligulate lobes on either side of median cleft and then a spinose process *affluens*, Brain. p. 206
6. Brachial plates bearing not more than 30 pseudospines; if with 25-30, they occupy not more than half the area of the plate 7
Brachial plates with not less than 40 pseudospines, which always occupy more than half the area of the plate 8
7. Brachial plates subcircular; pseudospines 9-12; anterior spiracles larger than brachial plate *minuta*, Morrison. p. 209
Brachial plates distinctly ovate and bearing from 25-30 pseudospines; anterior spiracles smaller than brachial plate *lobata*, sp. n. p. 208
8. Brachial plates subequilaterally triangular (Plate xx, K); antennae tipped by four long and one short setae *decorrella*, Mask. p. 210
Brachial plates roughly subovate or subtriangular but not subequilaterally so (Plate xx, M); antennae tipped by two long setae *theae*, Green & Mann. p. 210

Group of *Tachardina albida*, Cockerell.

Remarks.—This group is characterised by having the anal ring distinctly quadrately sectorised. Further than this it is difficult to go since most of the other available characters do not seem to follow this division with any degree of certainty. It is very possible that a better knowledge of the Asiatic and African *Tachardina* fauna will seriously modify my conclusions regarding relationships in this group.

Tachardina aurantiaca, Cockerell (Plate xx, I; text-fig. 8, G).

1903—*Tachardina aurantiaca*, Ckll., Can. Ent. xxxv, 65.

1912—*Tachardina aurantiaca*, Green, Tijdschr. Entom. iv, 314-316; Plate 12, 1-7.

1921—*Tachardina aurantiaca*, Morrison, Philipp. Journ. Sci. xviii, 6, 641.

Type Host and Locality.—Java: Garoet, on grape-fruit.

Other Records.—By Green. Java: Samarang, on *Flacourtia* and *Albizzia*. By Morrison. Malay Peninsula: Singapore, on *Ixora macrothyrsa*, *Acacia sphaerocephala* and *Cajanus indicus*.

Material Examined.—Singapore, on *Ixora macrothyrsa*. Material from Green.

Habit.—Verbatim from Cockerell: "On bark of branches; scales usually separate, sometimes coalescing, round seen from above, 4 mm. long, convex, but flattened dorsally, so that they are not half as high as broad; surface thrown more or less into concentric folds; colour bright orange; median dorsal area ferruginous. . . . Young up to about 2 mm. long, orange ferruginous, with rather obscure radiating ridges."

Morphology.—Antennae not observed; brachial plates irregularly subtriangular, bearing apically a gently depressed area with 16-17 pseudospines and basally a larger and deeper depression or crater with 30 pseudospines (Plate xx, I); anterior spiracles somewhat atypical, one end being almost circular, then tapering abruptly to the smaller, normally shaped end, with few pores; canellae distinct and about three times as long as spiracle itself; posterior spiracles as usual; dorsal spine typical, very easily detached and lost; marginal duct clusters 16 or 18, clusters subcircular in outline, ducts rather loosely clustered and of about 50 ducts (text-fig. 8, G); anal tubercle as broad as long, shaped as in *albida* and heavily chitinated; anal fringe broken in all available material, probably similar to *albida* or *actinella*; anal ring quadrately divided; anal ring setae typical of the long fringe type.

Remarks.—The affinities of this species are apparently with *albida*. The distinctive double-crater type of the brachial plate immediately distinguishes it from all species so far known. Length 2 mm.

Tachardina albida, Cockerell (Plate xx, s, t, w; and text-figs. 6, h, j, o; 7, b; 8, f, j).

1901—*Tachardina albida*, Ckll., The Entom. xxxiv, 249.

1920—*Tachardia albida*, Brain, Bull. Ent. Res. x, 126.

Type Host and Locality.—South Africa: Natal, Verulam, on *Mimosa* sp.

Other Records.—By Brain. Natal: Verulam, on *Acacia karoo*; Transvaal: Pienaars River, also on *Acacia karroo*.

Material Examined.—Part of type material. From Cockerell.

Habit.—From Cockerell: "Forming smooth yellowish white masses on twigs; the extremely dense and hard lac of the several individuals running together; masses up to 10 mm. in diameter and 30 mm. in length." The lac itself is extremely tough and brittle, somewhat resembling gutta-percha.

Morphology.—Antennae about five-segmented (Plate xx, w); brachia very long, membranous throughout; brachial plates large, subtriangular, with pseudospines (?) very numerous, covering more than half the area of the plate (Plate xx, t); apparently the pseudospines are of the structure shown in Plate xx, s, and not of the typical structure shown in Plate xx, d; anterior spiracles rather large, almost as long as brachial plate and with numerous pores (text-fig. 6, o), surrounded by a large cluster of scattered star pores, probably a modification of the canellae; posterior spiracles small but with numerous pores (text-fig. 6, j); dorsal spine apparently absent (?); marginal duct clusters 14 or perhaps 16, clusters well defined and rather compact, but showing a tendency to break up and form smaller associated groups (text-fig. 8, f); at the base of the supra-anal plate and on either side of it appear two small ovate duct clusters which may be true marginal ducts, in which case the number would be 16 (text-fig. 7, b₁); anal tubercle short; supra-anal plate as broad as long; anal fringe consisting of a large medio-distally slightly incised lobe on either side of the median cleft, then a caudo-laterally projecting ligulate lobe and then a short acute chitinous projection (text-fig. 7, b); anal ring quadrately lobed; anal ring setae projecting but little beyond tip of fringe. Length 4 mm.

Remarks.—Apparently most closely related to *aurantiaca*, although the relationship is certainly not close, as may be seen from a comparison of their diagnoses. The apparent absence of the dorsal spine does not seem to me to place this species in as typical a position as might at first be supposed. Then, too (as Green has strongly suggested), examination of further material will very probably prove it to be actually present. The agreement existing in other characters certainly does not seem to suggest the possibility of the species lacking so fundamental a character as the dorsal spine appears to be.

The brachial plates in second stage larvae are similar to those of the adult, except that the pseudospines are not so closely grouped. Cockerell remarks, concerning the mouth parts, that the "lobes oraux" (as figured by Targioni-Tozzetti in *T. lacca*) are very large, an observation that I have been unable to confirm with the material available.

Tachardina affluens, Brain (Plate xx, b; text-fig. 8, k).

1920—*Tachardia affluens*, Brain, Bull. Ent. Res. x, 125.

Type Host and Locality.—Union of South Africa: Pretoria, on *Euclea* sp. Brain states that it is "very common around Pretoria and apparently widespread throughout the Union."

Material Examined.—Part of the type material. From Green.

Habit.—Verbatim from Brain: "Test more or less globular, almost as deep as wide, sometimes slightly tapering to the top, about 3 mm. in diameter, yellowish to dull shellac brown, with a reddish spot in the centre. The test is generally smooth, but may show indications of faint ridges to the margins, which are prominent in young specimens."

Morphology.—Brachial plates triangular, pore or setose area apical and narrowly ovate, being twice as long as broad; apparently no true pseudospines present, but the material is so poor that this is not certain (Plate xx, B); it appears as if they are entirely replaced by true setae (Plate xx, B₁, B₂), which are borne upon small chitinous protuberances; anterior spiracles typical, but with only five or six pores; canellae thrice as long as spiracle itself; posterior spiracles as usual; dorsal spine distinctly longer than brachial plate; marginal duct clusters of about 25 or 26 rather loosely grouped ducts (text-fig. 8, K), clusters probably 16, but material was so poor that this could not be observed; supra-anal plate as broad as long; fringe consisting of a broad, truncate, ligulate lobe on either side of the anal cleft, then two acute lobes or processes; anal ring quadrately sectoried; anal ring setae scarcely as long as anal fringe. Length 2.2-5 mm.

Remarks.—The anal tubercle seems to place this species somewhere near *actinella*, but the differences are so great that the relationship can scarcely be close. Perhaps the most striking feature about this species is the brachial plates, where the pseudospines have apparently been replaced by true setae.

Tachardina actinella, Cockerell & King (Plates xi, X; xx, D, E, V; text-figs. 6, B, D, E; 7, D; 8, C).

1901—*Tachardia actinella*, Kll. & King, The Entom. xxxiv, 342.

1920—*Tachardia actinella*, Brain, Bull Ent. Res. x, 123.

Type Host and Locality.—South Africa: Natal, on unknown host.

Other Records.—Brain. Cape Colony: Qumba, on orange; East London and Grahamstown, on "native trees"; Natal, on pomegranate; Natal and Transvaal, on "native trees."

Material Examined.—Part of type material. From Cockerell.

Habit.—Test almost circular, sub-dome-shaped and with distinct flutings running to apex. Scales mostly separate, but occasionally two or more coalesce. Scale about 3 mm. long, 3 mm. broad, and scarcely 2 mm. high, dark crimson in colour, with about 16 strong but obtuse radiating yellowish white ridges.

Morphology.—Antennae six-segmented (Plate xx, V); brachia moderately long; brachial plates of the same size and shape as in *albida*, but with the ordinary type of pseudospines (Plate xx, D, E); anterior spiracles typical in shape and with few pores (text-fig. 6, D); canellae of scattered star pores, about twice as long as spiracle itself; posterior spiracles as usual (text-fig. 6, E); dorsal spine typical, distinctly shorter than brachial plate; marginal duct clusters apparently 14 in number, circular in shape and fairly compact (text-fig. 8, C); ventral duct clusters consisting of loosely grouped clusters of 15-17 small ducts (3 pairs?); supra-anal plate as long as broad; fringe very similar to that of *affluens*, consisting of first a long blunt ligulate lobe on either side of median cleft, then a slenderer, slightly more acute, lobe, and finally a spinose lobe or process (text-fig. 7, D); anal ring quadrately sectoried; anal ring setae projecting scarcely past anal fringe lobes; preceding the supra-anal plate there is a prominent pair of long chitinous rods or thickenings extending anteriorly from base of supra-anal plate to a position caudad of the dorsal spine, where there occurs a laterally pointing process of this same chitinous apodeme (text-fig. 6, B). Length 2 mm.

Remarks.—Most closely related to *affluens*. With *ternata* it agrees in possessing the curious internal apodeme described above, but the unsegmented character of

the anal ring in this latter species forces me to regard the development of this apodeme in the light of a parallelism, although it is possible that it should be considered the other way round.

Group of *Tachardina decorella*, Maskell.

Remarks.—This group, with the exception of *ternata*, forms a very compact group related by a number of good characters. The group as a whole is characterised by the presence of an unsegmented anal ring and by the very uniform type of anal tubercle and fringe (text-fig. 7, E, G, I, J). *T. ternata* is chiefly aberrant in possessing the peculiar, elongate pygidial apodemes shown in text-fig. 6, A, a character possessed in common with *T. actinella* of the group of *T. albida*.

Tachardina ternata, sp. n. (Plates xi, EE; xx, C; text-figs. 6, A, C, F; 8, H).

Type Host and Locality.—India: Travancore, on *Acacia sundra* (S. Mahdihassan). My thanks are due to Mr. Green for his kind permission to describe this species. The name is Mr. Green's MS. designation for it.

Hab.—Tests more or less massed on twigs; subglobular and subtrilobate, with indistinct flutings running from base to apex. Colour, a dirty reddish brown. Height 1.5 mm., diameter 2.5–3 mm.

Morphology.—Antennae typical, tipped by three setae; brachial plates distinctly ovate, about 1.5 times as long as broad, the pseudospinous area subcircular and almost median, not at all depressed and occupying about half the area of the brachial plate (Plate xx, C); spiracles reversed; anterior spiracles typical in shape but rather small (text-fig. 6, C), being distinctly smaller than brachial plate; canellae occupying a space 1.5 times the area of the spiracle itself; posterior spiracles small; anal spine of usual shape, subequal in length to brachial plate; marginal duct clusters about 16, clusters themselves subcircular and fairly compact (text-fig. 8, H); clusters of a very distinctive duplex type as shown in figure; anal tubercle with a profile as in *lobata*; anal fringe consisting of two distinct pairs of ligulate lobes on either side of median cleft, as is typical for the group; anal ring entire; anal ring setae projecting a little beyond anal fringe; with a distinct pair of elongate pygidial apodemes, as described for *actinella*, but not so heavily chitinised as in that species, although as large. Length 1.5–2 mm.

Remarks.—This species occupies a rather isolated position, as indicated by the pygidial apodemes, the reversion of spiracles and the peculiar marginal clusters. This species and *Afrotachardina brachyselosa* are the only two species outside of the genus *Tachardia* where this reversion of spiracles takes place, so far as I know.

Tachardina lobata, sp. n. (Plates x, B; xx, J, Q, U; text-figs. 6, I, L; 7, C, G; 8, L, M). 1922—*Tachardina minuta* (Morrison), Green, Coccidae of Ceylon. v, 414–416; clxxiii (misidentification).

Type Host and Locality.—Ceylon: Peradeniya, on *Fluggea leucopyrus*.

Previous Records.—Green. Ceylon: Peradeniya, on *Flacourtia ramontchi* and *Fluggea leucopyrus*. Southern India, on Coffee, *Thespesia populnea*, *Michelia champaca* and *Pongamia glomerata*. I have seen material only from *Fluggea*.

Hab.—Verbatim from Green: "The resinous case of the adult female varies—in colour—from bright castaneous to dark reddish brown. In old examples the colour is often obscured by a coating of black fungus. The surface is minutely and irregularly rugulose. Length 1.75–2.0 mm., breadth 1.25–1.75 mm. . . . On small branches of . . . hosts."

Morphology.—Antennae small, segmentation lost or at least very obscure (Plate xx, U); brachia moderately long; brachial plates small, almost ovate, with a small group of pseudospines, which number 25–30 and do not cover more than half the area of the brachial plate (Plate xx, J); anterior spiracles simple and with no

pores, distinctly a little smaller than brachial plate (text-fig. 6, L); canellae much reduced, consisting of a few star pores close to spiracle; posterior spiracles typical (text-fig. 6, I); dorsal spine entirely typical, almost as long as brachial plate (Plate xx, Q); marginal duct clusters 16, rather highly differentiated, as shown in Plate x, B, anterior pair large, circular, subequal to brachial plate, the next three pairs, one anterior to brachia and two posterior, are small, circular, and subequal to anterior spiracle (text-fig. 8, M), then three pairs of distinctly elliptical and rather large clusters, almost as large as anterior cluster (Plate x, B; and text-fig. 8, L), and last of all a pair of very small clusters adjacent to the anal tubercle; apparently with three pairs of ventral clusters which consist of 6-8 minute ducts each; anal tubercle and fringe typical (text-fig. 7, C, G). Length 1-2 mm.

Remarks.—Green states: "Although I have known of this insect for more than 20 years and have distributed specimens under the MS. name of *lobata*, no formal description of the species has appeared in print until quite recently, when it has been described by Morrison from examples collected in the Philippine Islands. Ceylon examples differ from the type only in the more elongate form of the perforate stigmatic plates."

I cannot agree with Green that this form is synonymous with *minuta*. Besides the difference noted by Green, there is a marked difference in the arrangement of the pseudospines, as well as in their number, and a difference in the comparative sizes of the anterior spiracle and brachial plate. In *minuta* the spiracle exceeds the brachial plate in size, while the reverse is the case in *lobata*. Taking everything into consideration, it is believed the best procedure, for the present at least, to regard the two as distinct.

Green records the Chalcid parasite, *Marietia leopardi*, Motsch., from this species.

***Tachardina minuta*, Morrison (Plate xx, O; text-fig. 8, N).**

1920—*Tachardia minuta*, Morrison, Philipp. Journ. Sci. xvii, 179; fig. 21, Plate 1: 4.

Type Host and Locality.—Philippine Islands: Isabela, Basilon, on *Mangifera indica*.

Habit.—On leaves of host, mostly on the underside of the midrib; test somewhat egg-shaped, broadest behind but with a constriction on each side about the middle, strongly convex, broadly ribbed laterally; length about 1.5 mm.; colour dark reddish to almost black.

Morphology.—Antennae short, two-segmented, tipped by two long and two short setae; brachia elongate, cylindrical; brachial plates small, subovate, bearing a loosely grouped cluster of 11-15 pseudospines and several small setae, which in all occupy considerably more than half the area of the brachial plate itself (Plate xx, O); canellae represented by a "few quinquelocular pores near the spiracle"; posterior spiracles typical; dorsal spine typical in shape and almost twice as long as breadth of brachial plate; anal tubercle apparently typical; with 16 circular marginal pore clusters (text-fig. 8, N) arranged as in *lobata*, but apparently not differentiated as in that species; with four pairs of ventral clusters, of which the anteriors are largest, also it is apparently the only pair anterior to the brachia.

Remarks.—The above description is a modification of that given by Morrison. I have not seen specimens of this species.

Green, in his "Coccidae of Ceylon," Part V, records a species under this name from India, but careful study has convinced me that he is in error, and hence his species is here described as *T. lobata*, sp. n.

Morrison describes and figures the first stage larva of this species.

Tachardina theae, Green & Mann (Plate xi, HH; xx, M, X; text-figs. 6, M; 7, I, J; 8, B, E).

1907—*Tachardina decorella* var. *theae*, Green & Mann, Mem. Dep. Agr. India. Ent. Ser. 1, 5, 348; figs. 16, 17, 18.

1895—*Tachardina decorella*, Maskell, Trans. N.Z. Inst. xxviii, 408 (misidentification).

1896—*Tachardina decorella*, Maskell, Ind. Mus. Notes. iv, 2, 58 (misidentification).

1907—*Tachardina decorella* var. *theae*, Green & Mann, Green, Mem. Dep. Agr. India. Ent. Ser. ii, 28.

1921—*Tachardina decorella* (Mask.), Ferris, Bull. Ent. Res. xii, 212 (misidentification).

Type Host and Locality.—India: Darjeeling, on tea plants.

Other Records.—Besides the above, Green recorded it in the original description as from Assam on tea plants and from Darjeeling on *Cinchona calisaya*. Maskell: India, on tea plants and "forest trees." Ferris: Formosa, Taihoku, on *Ficus retusa* and on an unknown host.

Material Examined.—Part of type material from tea and *Cinchona calisaya* at Darjeeling. Formosa, on *Ficus retusa* and an unknown host. China: Hong Kong, on *Gardenia florida*. India: Calcutta, on *Ficus religiosa*. Indian material from Green. Formosan material from Prof. E. O. Essig, of the University of California. Chinese material from the Bremner Collection of Coccidae.

Habit.—After Green.—Differs from *decorella* in the corrugations of the test being broken into more or less distinct rounded tubercles; these corrugations may extend to the margin but usually stop short of it. Lac very hard and horny—does not soften in KOH.

According to Green this species is occasionally so abundant as to ruin certain isolated tea plants.

Morphology.—Antennae obscurely segmented, tipped by two long setae (Plate xx, x); brachial plates medium-sized, more or less elongate ovate or subtriangular, with a group of pseudospines that cover more than half the total area of the plate (Plate xx, M); anterior spiracles typical in shape, with few pores, much shorter than brachial plate (text-fig. 6, M); canellae consisting of a group of star pores the same size as the spiracle; posterior spiracles typical; dorsal spine of the usual shape, longer than anterior spiracle but shorter than brachial plate; marginal duct clusters very distinct, 16 in all; ducts closely clustered, much more so than in *decorella* (text-fig. 8, B); ventral duct clusters numbering three pairs, consisting of small, very loosely clustered groups of 12 or 13 ducts; anal tubercle typical (text-fig. 7, I, J) except that the profile is less pronouncedly humped than in *lobata* or *ternata*. Length 2.2–5 mm.

Remarks.—This species is somewhat variable in the proportions and shapes of the parts, but nevertheless is very constant in its general features. There are apparently distinguishable differences between Formosan and Indian specimens, but they are too slight and too easily bridged by intermediates to consider in this place. There is a possibility that more material may show that they could be regarded in the light of subspecies.

This species is most closely related to *decorella*, but is easily separable by a number of characters such as the brachial plates and marginal duct clusters.

Tachardina decorella, Maskell (Plate xx, K; text-figs. 6, N; 7, E; 8, I).

1892—*Carteria decorella*, Mask., Trans. N.Z. Inst. xxv, 247; Plate xviii, 12–20.

1894—*Tachardina decorella*, Maskell, Trans. N.Z. Inst. xxvii, 70.

1900—*Tachardina decorella*, Froggatt, Scale Ins. Lac. 4.

Other records of *T. decorella* are for the most part referable to *T. theae*, Green.

Type Host and Locality.—Australia: New South Wales, Sydney, on *Myrica cerifera*.

Other Records.—New South Wales and Victoria, on various hosts, among which are *Styphelia* (*Monotoca*) *elliptica* and *Eugenia smithi*. Formerly regarded as ranging through India, China and Australia, but with the separation of *theae* as a distinct species its range is entirely reduced to Australia.

Material Examined.—Sydney, New South Wales, on *Eugenia smithi*. From Green.

Habit.—From Maskell: "Adult female covered by a wax test, which at first single and separate becomes later aggregated in masses on the twig. The normal form of the test is subcircular, rather convex; the colour yellowish brown, the diameter would average about 4 mm. if separated at full growth."

Morphology.—Antennae obscurely segmented, tipped by four long and one short setae; brachial plates small, almost equilaterally triangular and with a compact, large, apical, subcircular cluster of pseudospines (Plate xx, κ); anterior spiracles small, with few pores, as long as brachial plate and almost as long as dorsal spine (text-fig. 6, η); canellae small, covering an area the size of the spiracle itself; posterior spiracles typical; dorsal spine of usual shape, subequal in length to brachial plate; marginal duct clusters 14 or 15, much more inconspicuous than in *theae* and with ducts themselves smaller and more loosely clustered than in that species (text-fig. 8, ι); anal tubercle similar to that of *theae*, differing slightly in the fringe, the lobes averaging more angular than in *theae* (text-fig. 7, ε). Length 2 mm.

Remarks.—Most closely related to *theae*, from which it differs in the relative sizes of the brachial plates, the type of marginal duct clusters, etc.

Unexamined and Doubtful Species.

The following forms are not sufficiently well described or known to allow of their being placed in the keys or in their proper systematic positions:—

Tachardina minor, Brain (Plate xx, ρ).

1920—*Tachardina minor*, Brain, Bull. Ent. Res. x, 124.

Type Host and Locality.—Montague, C.P., on "rhenosterbosch," *Elytropappus rhinocerotis*, Less.

Habit.—Female test 1.5–2 mm. in diameter, rich castaneous brown, with larval cast conspicuous. Viewed from above the test is broad heart shaped. Usually solitary on twigs.

Morphology.—Antennae obscurely 3–4-segmented; brachial plates varying from 57–68 μ long by 48 μ wide; with from 14–28 pores (Plate xx, ρ); anterior spiracles with 16 pores; vestigial legs present as minute conical spines; dorsal spine as long or longer than greatest length of brachial plate, 68 μ long by 54 μ broad at base; anal plate almost semicircular, with the basal portion rugose and its apex four-lobed.

Remarks.—The above description gives everything of importance in Brain's original description. There is no reason for supposing that this species differs in any fundamental character as regards the marginal or other ducts, and as shown by Brain's description it is typical in other respects. The remark concerning the anal plate seems to indicate that it will possibly fall into the *decorella* group.

Tachardina karroo, Brain (Plate xx, l).

1920—*Tachardina karroo*, Brain, Bull. Ent. Res. x, 124.

Type Host and Locality.—Montague, C.P., on "rhenosterbosch," *Elytropappus rhinocerotis*, Less., in association with *T. minor*.

Habit.—Female test 2.5–3.5 mm. in diameter, sometimes solitary but usually massed together on the thicker stems of the plant. Somewhat similar to *T. minor*

but more spherical, larger and paler in colour. In a number of cases the test is semi-transparent, deep amber yellow with three distinct pale lines radiating from the median dorsal ridge to the margins in the form of a broad Y.

Morphology.—Antennae obscurely three-segmented and tipped by 3-4 short setae; brachial plate about 120μ long by 110μ broad, with 62-84 pores (Plate xx, L); anterior spiracles with 2-3 simple pores; dorsal spine about 90μ long by 78μ broad at the base; supra-anal plate broader than long, basal portion coarsely wrinkled; anal fringe with four small pointed lobes.

Remarks.—All of value in Brain's original description is incorporated in the above diagnosis. There is no indication that it is in any way atypical.

Tachardina decorella (Maskell), Brain. (Misidentification.) (Plate xx, F, R.)

1920—*Tachardia decorella* (Mask.), Brain, Bull. Ent. Res. x, 125. (Misidentification).

Records.—Transvaal, Crocodile River, on *Acacia karroo*, L. Pretoria, Zoological Gardens, on *Acacia karroo*.

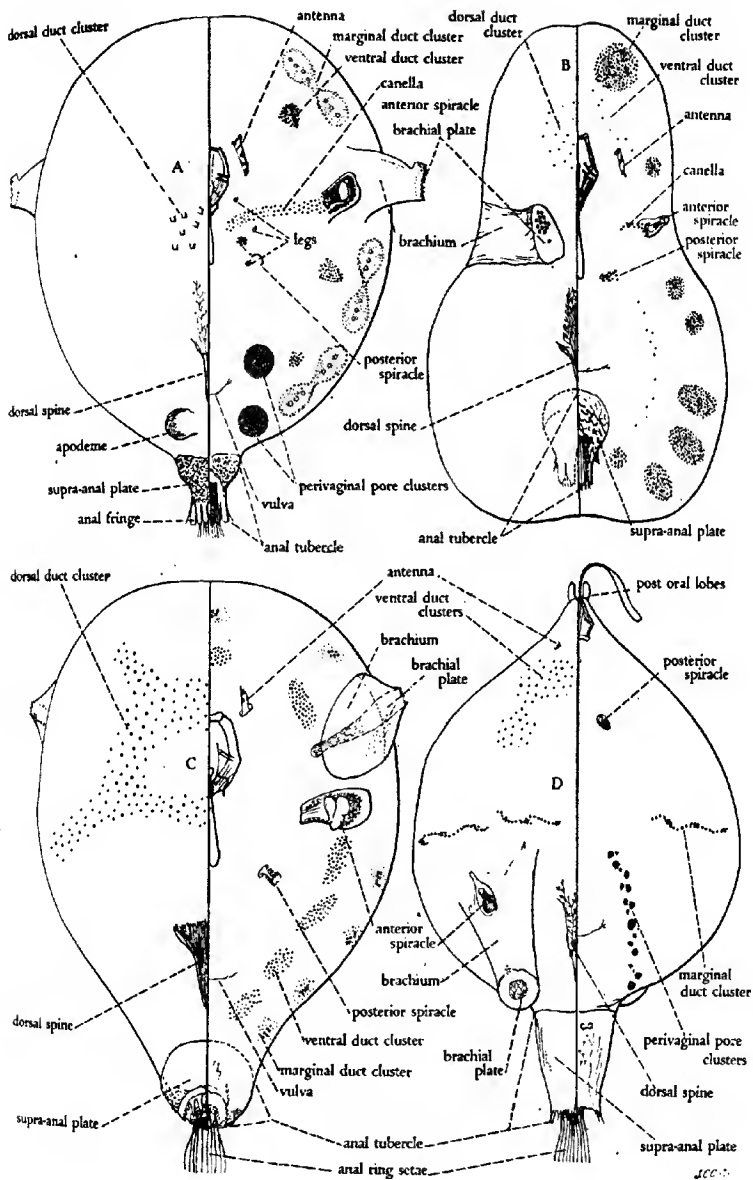
Habit.—Female tests generally coalesce so as to form a mass completely surrounding the thin twigs of the host plant for a distance of from 30-40 mm. Individual tests almost globular but flattened above, 3-4 mm. in diameter, deep purplish brown to almost black, with dull grey speckles arranged in radiating ridges, intermediate spaces glossy. Lac hard and brittle.

Morphology.—Brachial plates about 170μ long and with over 100 pores (Plate xx, F); dorsal spine almost as broad as long, $120-121\mu$, abruptly narrowed two-thirds its way from the apex (Plate xx, R); anal plate about 190μ broad by 170μ long, with the basal portion embossed with a very fine "grease-spot" design; marginal clusters present.

Remarks.—There is no doubt that this is a misidentification, as may be seen by comparing the brachial plate, as figured by Brain, with the brachial plate of true *decorella*. The description given is too inadequate to form any judgment of value concerning this species except that it certainly is not *decorella* and that it is possibly a new species. The final disposition of this species must be made by some one with material at hand.

EXPLANATION OF PLATE X.

Diagrammatic figures of generic "types." A. *Tachardiella bodkini*, Newst. with addition of canella, legs and dorsal duct cluster, characters not observed in this species. B. *Tachardina lobata*, sp. n. C. *Austrotachardia angulata*, Frogg. D. *Tachardia lacca*, Kerr.

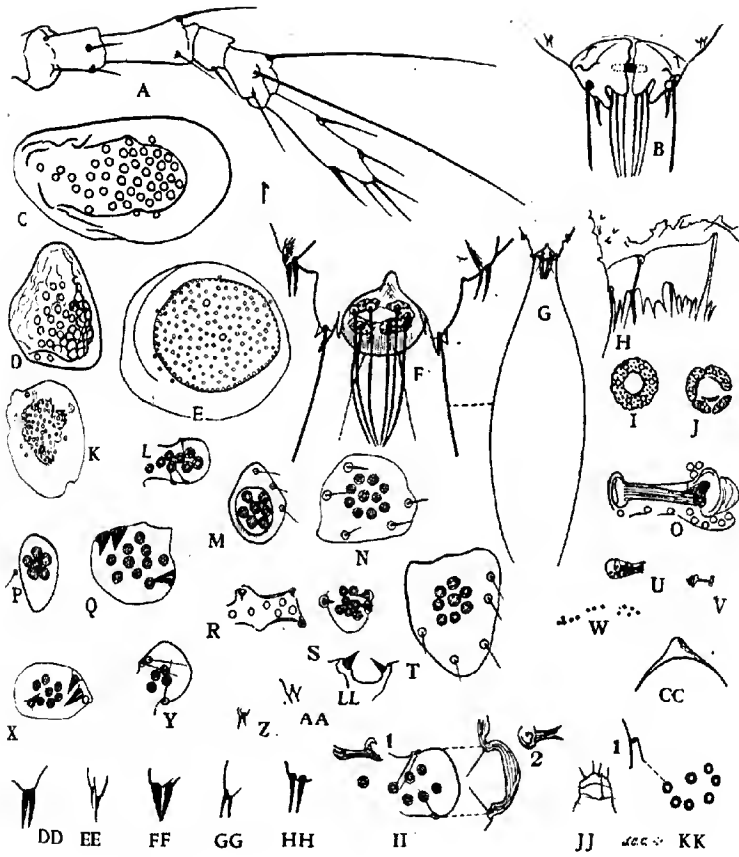


EXPLANATION OF PLATE XI.

First and second stage larval structures. f.s. indicates "first stage," s.s. "second stage."

- A. *Tachardiella larreae*, f.s. antenna.
- B. *Tachardiella larreae*, f.s. dorsal aspect of pygidial region, showing completely divided supra-anal plate and bordering setae.
- C. *Tachardiella texana*, s.s. brachial plate.
- D. *Tachardiella larreae*, s.s. brachial plate.
- E. *Tachardia fici*, s.s. brachial plate.
- F. *Tachardia ebrachiata*, f.s. supra-anal plate, showing fringe lobes, lateral setae and pseudocerarii, also quadrate anal ring and the anal ring setae.
- G. *Tachardia ebrachiata*, f.s. same as "F" but on a smaller scale to show the great length of the lateral setae.
- H. *Tachardia* sp. (Formosa), s.s. dorsal aspect of anal fringe.
- I. *Metatachardia conchiferata*, f.s. terminal aspect of anal ring.
- J. *Tachardiella larreae*, f.s. terminal aspect of anal ring, showing four-sectored type.
- K. *Tachardia* sp. (Formosa), s.s. brachial plate.
- L. *Austrotachardiella cydoniae*, f.s. brachial plate.
- M. *Tachardia meridionalis*, f.s. brachial plate.
- N. *Tachardia lacca*, f.s. brachial plate.
- O. *Tachardiella larreae*, s.s. anterior spiracle.
- P. *Metatachardia conchiferata*, f.s. brachial plate.
- Q. *Austrotachardia australis*, f.s. brachial plate.
- R. *Austrotachardia acaciae*, f.s. brachial plate.
- S. *Austrotachardia angulata*, f.s. brachial plate.
- T. *Tachardia ebrachiata*, f.s. brachial plate.
- U. *Tachardia* sp. (Formosa), s.s. anterior spiracle.
- V. *Tachardia* sp. (Formosa), s.s. posterior spiracle.
- W. *Tachardia* sp. (Formosa), s.s. marginal duct cluster.
- X. *Tachardina actinella*, f.s. brachial plate.
- Y. *Tachardiella glomerella*, f.s. brachial plate.
- Z. *Tachardiella larreae*, f.s. pseudocerarius.
- AA. *Tachardiella glomerella*, f.s. pseudocerarius.
- CC. *Tachardiella texana*, s.s. dorsal spine.
- DD. *Afrotachardina brachysetosa*, f.s. pseudocerarius.
- EE. *Tachardina ternata*, f.s. pseudocerarius.
- FF. *Austrotachardia acaciae*, f.s. pseudocerarius.
- GG. *Metatachardia conchiferata*, f.s. pseudocerarius.
- HH. *Tachardina theae*, f.s. pseudocerarius.
- II. *Tachardiella larreae*, f.s. brachial plate and anterior spiracle; (1) terminal aspect; (2) lateral aspect.
- JJ. *Tachardia* sp. (Formosa), s.s. antenna.
- KK. *Tachardiella texana*, s.s. marginal ducts; (1) lateral aspect.
- LL. *Tachardiella texana*, f.s. lateral aspect of brachial depression.

Figures of homologous parts, excepting G, K, O and KK, are upon the same scale of magnification.

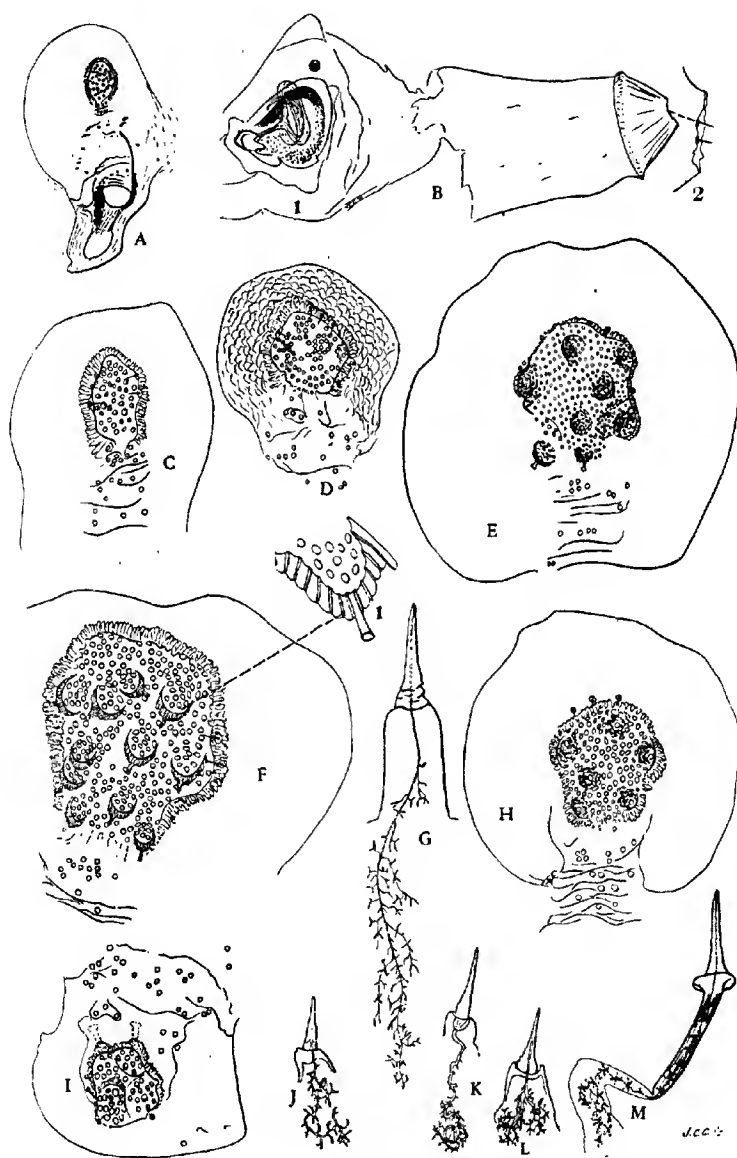


EXPLANATION OF PLATE XII.

Tachardia and *Metatarchardia*.

- A. *T. albizziae*, brachial plate, brachium and anterior spiracle, showing the complete fusion of those parts.
- B. *M. conchiferata*, anterior spiracle and lateral aspect of brachium; (1) anterior spiracle; (2) lateral aspect of crater rim.
- C. *T. albizziae*, brachial plate.
- D. *T. meridionalis*, brachial plate.
- E. *T. ebrachiata*, brachial plate.
- F. *T. lacca*, brachial plate; (1) diagrammatic cross-section through dimple to show pores and nuclear duct.
- G. *T. ebrachiata*, dorsal spine, ducts and pedicel.
- H. *T. fici*, brachial plate.
- I. *T. greeni*, brachial plate.
- J. *T. meridionalis*, dorsal spine, ducts and pedicel.
- K. *T. greeni*, dorsal spine and ducts.
- L. *T. albizziae*, dorsal spine and ducts.
- M. *M. conchiferata*, dorsal spine and ducts, showing the *internal* chitinous sheath surrounding the ducts.

Figures of homologous parts, excepting A, B and F₁, are upon the same scale of magnification.



EXPLANATION OF PLATE XIII.

Tachardia and *Metatarchardia*.

- A. *M. conchiferata*, anterior ventral duct cluster; (1) individual duct.
- B. *T. greeni*, marginal duct cluster; (1) nuclear duct; (2) duplex duct.
- C. } *T. fici*, marginal duct clusters; (c₁) individual duct.
- D. }
- E. *T. meridionalis*, marginal duct cluster; (1) individual duct.
- F. *T. lacca*, marginal duct cluster; (1) individual duct.
- G. *T. ebrachiata*, marginal duct cluster; (1) individual duct.
- H. *M. conchiferata*, marginal duct cluster; (1) individual duct.
- I. *T. albizziae*, marginal duct cluster; (1) nuclear ducts.
- J. *M. conchiferata*, spermatozoid ducts.
- K. *T. lacca*, antenna.
- L. *T. greeni*, antenna.
- M. *T. meridionalis*, antenna.
- N. *T. fici*, antenna.
- O. *T. fici*, ventral duct.
- P. *T. meridionalis*, mouth parts cluster of ducts.
- Q. *M. conchiferata*, antenna.
- R. *T. albizziae*, antenna.
- S. *T. lacca*, posterior spiracle. (Same magnification as v.)
- T. *T. fici*, anterior spiracle.
- U. *T. ebrachiata*, anterior spiracle.
- V. *T. lacca*, anterior spiracle. (Same magnification as s.)
- W. *T. ebrachiata*, antenna.

All figures of homologous parts are upon the same scale of magnification.

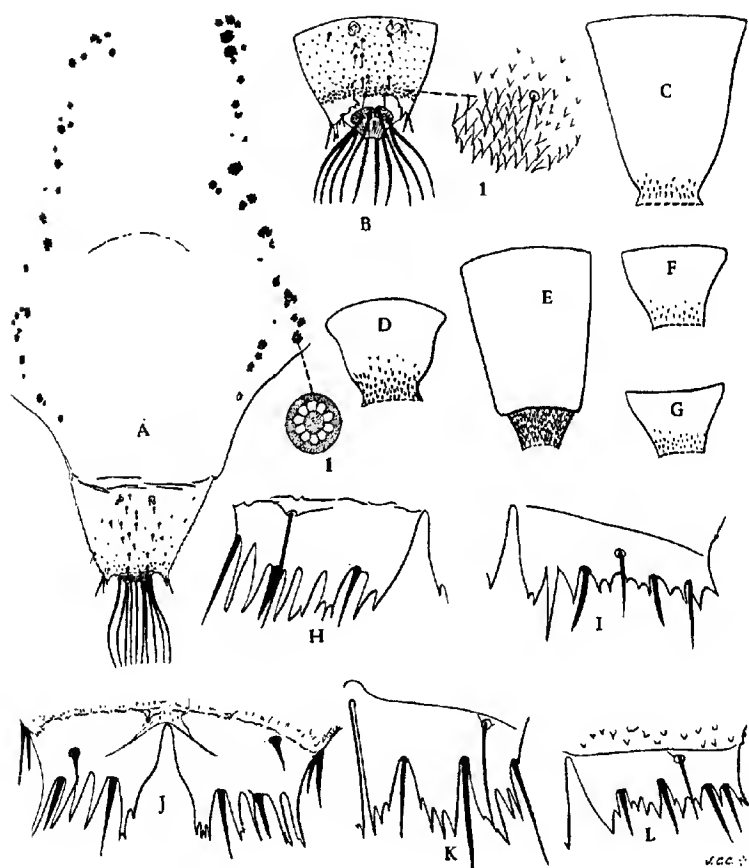


EXPLANATION OF PLATE XIV.

Tachardia and *Metatachardia*.

- A. *T. greeni*, ventral aspect of anal tubercle, vulva and perivaginal pore clusters;
(1) an individual perivaginal pore.
- B. *T. fici*, ventral aspect of anal tubercle ; (1) enlarged portion of chitinous part
showing the hispid character.
- C. *T. lacca*, supra-anal plate.
- D. *T. fici*, supra-anal plate.
- E. *M. conchiferata*, supra-anal and pre-supra-anal plate.
- F. *T. albizziae*, supra-anal plate.
- G. *T. greeni*, supra-anal plate.
- H. *T. lacca*, anal fringe.
- I. *T. greeni*, anal fringe.
- J. *T. albizziae*, anal fringe.
- K. *T. fici*, anal fringe.
- L. *T. meridionalis*, anal fringe.

All strictly comparable figures are upon the same scale of magnification.

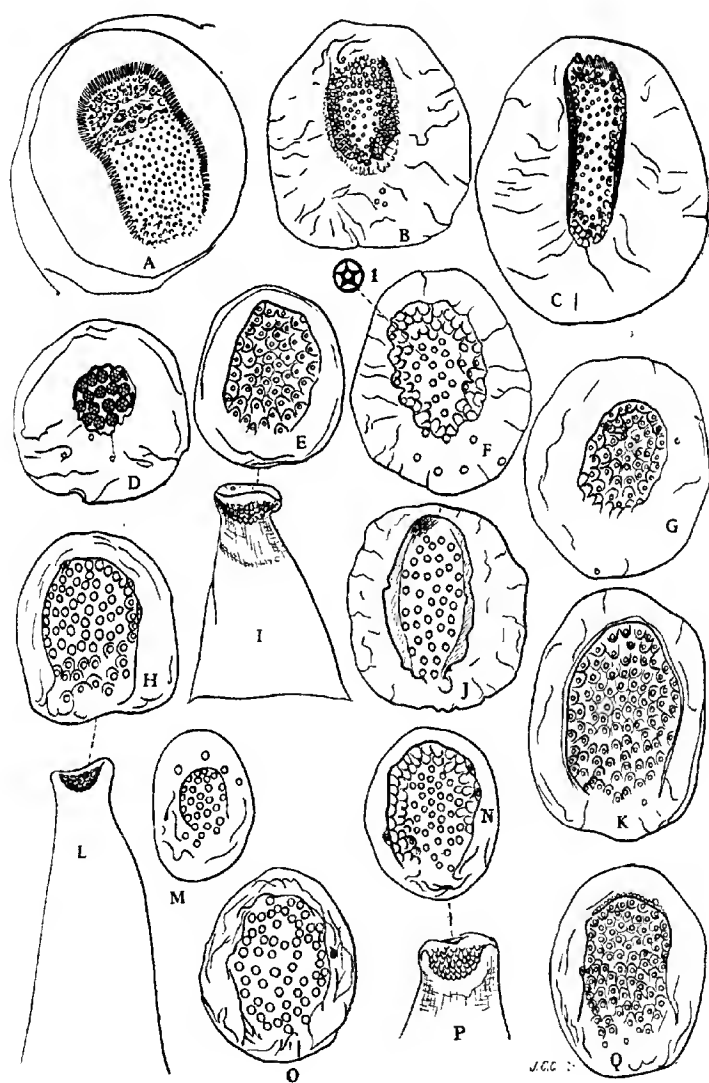


EXPLANATION OF PLATE XV.

Tachardiella. Brachial plates and brachia.

- A. *T. ingae*.
- B. *T. mexicana*.
- C. *T. texana*.
- D. *T. lycii*.
- E. *T. cornuta*.
- F. *T. ferrisi*; (1) individual pore showing loculi.
- G. *T. fulgens*.
- H. *T. larreae*.
- I. *T. cornuta*.
- J. *T. parva*.
- K. *T. larreae* f. *californica*.
- L. *T. larreae*.
- M. *T. larreae*, second stage larva.
- N-P. *T. glomerella*.
- O. *T. pustulata*.
- Q. *T. glomerella* f. *baccharidis*.

Figures A, B and C are drawn upon a smaller scale than the figures of the rest of the brachial plates. Figures L, I and P are upon the same scale.

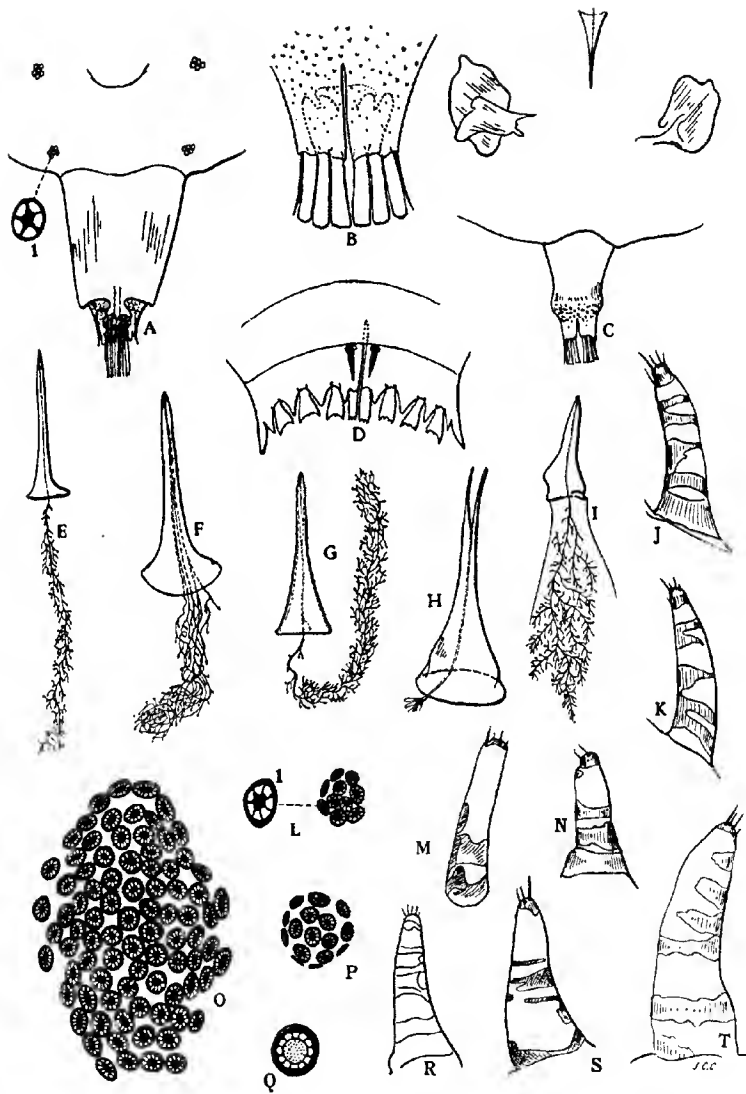


EXPLANATION OF PLATE XVI.

Tachardiella and *Austrotachardiella*.

- A. *T. cornuta*, ventral aspect of pygidial region showing anal tubercle, vulva and perivaginal pore clusters; (1) individual perivaginal pore.
- B. *A. rotundata*, dorsal aspect of anal fringe; "long fringe type."
- C. *A. rotundata*, dorsal aspect of pygidial area showing chitinous apodemes, anal tubercle and position of dorsal spine.
- D. *T. cornuta*, dorsal aspect of anal fringe; "short-fringe type."
- E. *T. gemmifera*, dorsal spine and ducts.
- F. *T. parva*, dorsal spine and ducts.
- G. *A. rotundata*, dorsal spine and ducts.
- H. *T. ferrisi*, dorsal spine.
- I. *T. texana*, dorsal spine and ducts.
- J. *T. pustulata*, antenna.
- K. *T. glomerella*, antenna.
- L. *T. cornuta*, perivaginal pore cluster; (1) individual perivaginal pore.
- M. *T. cornuta*, antenna.
- N. *T. lycii*, antenna.
- O. *A. rubra*, perivaginal pore cluster.
- P. *T. larreae*, perivaginal pore cluster.
- Q. *T. glomerella*, individual perivaginal pore showing locular details.
- R. *T. larreae*, antenna.
- S. *T. ferrisi*, antenna.
- T. *T. glomerella* f. *baccharidis*, antenna.

All figures of similar parts are upon the same scale, with the exception of H and Q.

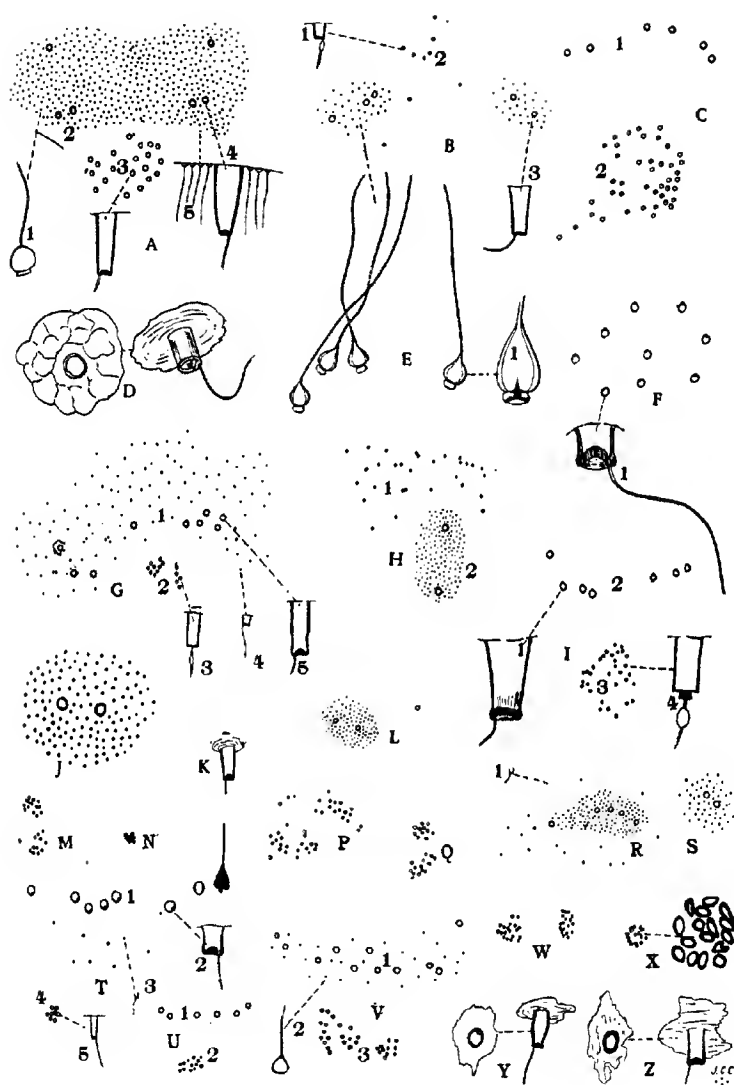


EXPLANATION OF PLATE XVII.

Tachardiella.

- A. *T. texana*, posterior marginal and ventral duct clusters; (1) spermatozoid or duplex duct; (2) marginal duplex cluster; (3) ventral cluster; (4) nuclear duct; (5) dermal terminations of duplex or spermatozoid ducts.
- B. *T. lycii*, posterior marginal and ventral duct clusters; (1) and (2) ventral duct cluster and individual duct; (3) nuclear duct of marginal cluster.
- C. *T. ingae*, anterior ventral and marginal duct clusters; (1) marginal cluster; (2) ventral cluster.
- D. *T. fulgens*, details of dorsal duct.
- E. *T. lycii*, internal terminations of duplex or spermatozoid ducts; (1) structural details of duplex duct.
- F. *T. cornuta*, dorsal duct cluster; (1) individual dorsal duct showing structural details.
- G. *T. fulgens*, posterior marginal and ventral duct clusters; (1) marginal duplex cluster; (2) ventral cluster; (3) ventral duct; (4) duplex duct; (5) nuclear duct. (3, 4 and 5 to the same scale.)
- H. *T. parva*, posterior marginal and ventral duct clusters; (1) ventral cluster; (2) marginal duplex cluster.
- I. *T. ferrisi*, anterior ventral and marginal duct clusters; (1) individual marginal duct; (2) marginal cluster; (3) ventral cluster; (4) individual ventral duct.
- J. *T. glomerella*, median marginal duct cluster showing details of clusters of the duplex type.
- K. *T. glomerella*, individual dorsal duct.
- L. *T. glomerella* f. *baccharidis*, median marginal duct cluster.
- M. *T. glomerella*, anterior ventral duct cluster.
- N. *T. glomerella*, median ventral duct cluster.
- O. *T. cornuta*, internal termination of spermatozoid duct.
- P. *T. glomerella* f. *baccharidis*, anterior ventral duct cluster.
- Q. *T. glomerella* f. *baccharidis*, median ventral duct cluster.
- R. *T. pustulata*, posterior marginal duct cluster; (1) individual accessory, ventral (?), or triplex (?) duct.
- S. *T. pustulata*, median marginal duct cluster.
- T. *T. cornuta*, anterior marginal and ventral duct clusters; (1) marginal cluster; (2) nuclear duct; (3) one of the scattered auxiliary or duplex ducts; (4) ventral cluster; (5) individual ventral duct.
- U. *T. larreae*, anterior marginal and ventral duct clusters; (1) marginal cluster; (2) ventral cluster.
- V. *T. larreae* f. *californica*, anterior ventral and marginal duct clusters; (1) marginal cluster; (2) internal termination of spermatozoid or duplex duct; (3) ventral cluster.
- W. *T. pustulata*, divided anterior ventral duct cluster.
- X. *T. pustulata*, median ventral duct cluster.
- Y. *T. larreae* f. *californica*, individual dorsal duct.
- Z. *T. pustulata*, individual dorsal duct.

All general figures of clusters with the exception of J are of the same magnification. Detailed drawings and subfigures are not necessarily directly comparable except within the species.



EXPLANATION OF PLATE XVIII.

Tachardiella and *Austrotachardiella*.

- A. *T. fulgens*, anterior spiracle.
- B. *T. cornuta*, anterior spiracle.
- C. *T. mexicana*, anterior spiracle.
- D. *A. rotundata*, anterior spiracle.
- E. *T. cornuta*, canella pore, showing structural details. Lateral and terminal aspects.
- F. *A. rotundata*, posterior spiracle.
- G. *T. cornuta*, posterior spiracle.
- H. *T. larreae*, anterior spiracle.
- I. *A. nigra*, anterior spiracle.
- J. *A. gemmifera*, anterior spiracle.
- K. *T. mexicana*, posterior spiracle.
- L. *T. larreae*, four-sectored type of anal ring.
- M. *T. pustulata*, anterior spiracle and canella.
- N. *T. glomerella*, anterior spiracle, canella and posterior spiracle, showing the intimate connection between the three.
- O. *T. glomerella*, canella pore, lateral and terminal aspects.
- P. *T. glomerella* f. *baccharidis*, anterior spiracle, canella and posterior spiracle, showing the intimate connection between the three.
- Q. *T. ingae*, anterior spiracle and canella.
- R. *T. lycii*, anterior spiracle and canella; (1) canella pore.
- S. *T. mexicana*, leg (*fulvoradiata*).
- T. *T. mexicana*, leg (*mexicana*).
- U. *T. cornuta*, leg.
- V. *T. parva*, leg.
- W. *A. cydoniae*, leg.
- X. *T. larreae*, leg.
- Y. *A. gemmifera*, leg.
- Z. *T. ferrisi*, leg.
- AA. *T. ingae*, leg.
- BB. *T. texana*, leg.
- CC. *T. lycii*, leg.

Figures not necessarily drawn to the same scale.

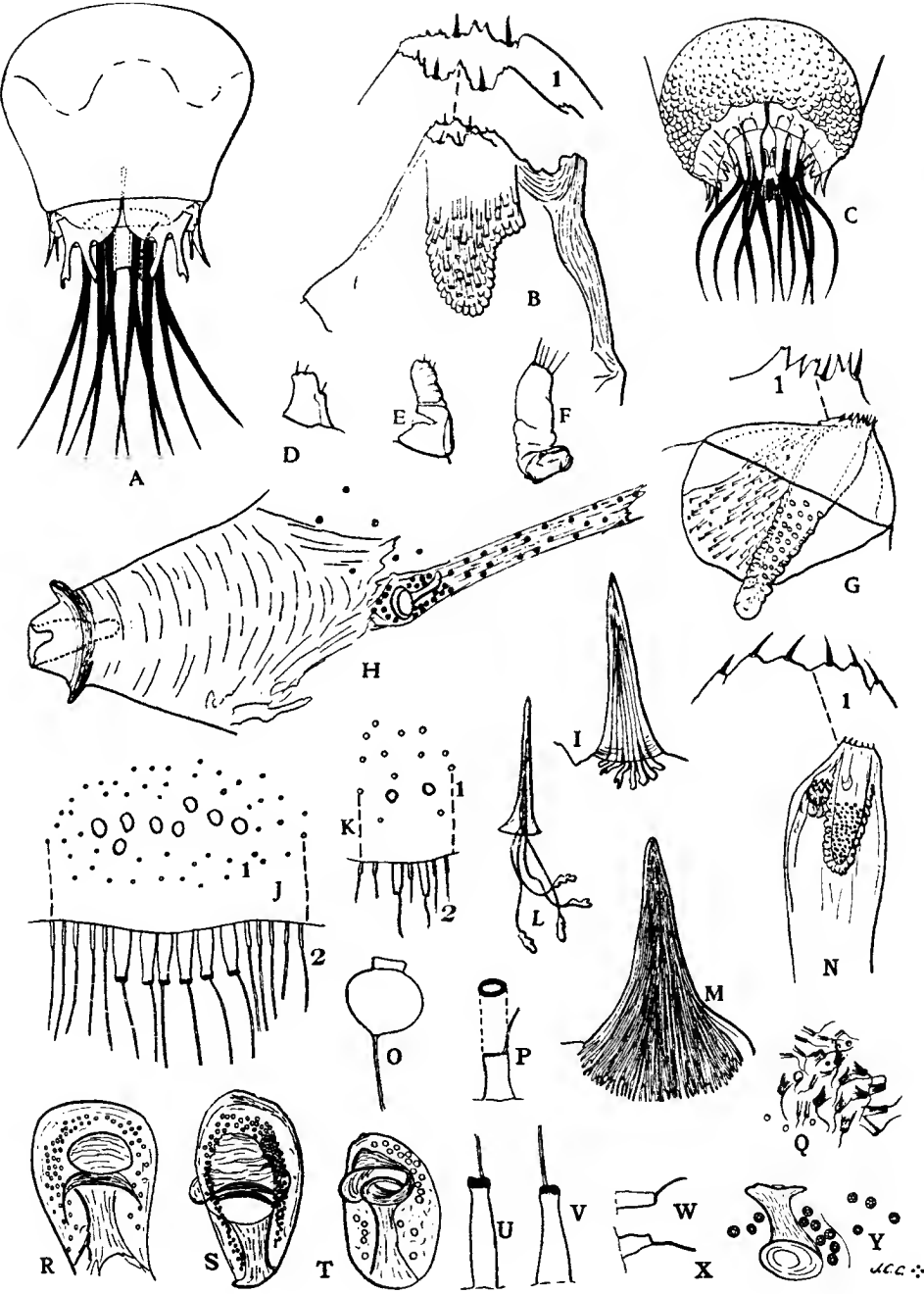


EXPLANATION OF PLATE XIX.

Austrotachardia.

- A. *A. melaleucaae*, dorsal aspect of anal tubercle, showing supra-anal plate, anal fringe and anal ring setae.
- B. *A. melaleucaae*, lateral aspect of brachium and crater; (1) details of crater fringe.
- C. *A. angulata*, dorsal aspect of anal tubercle, showing supra-anal plate, anal fringe and anal ring setae.
- D. *A. melaleucaae*, antenna.
- E. *A. australis*, antenna.
- F. *A. angulata*, antenna.
- G. *A. angulata*, lateral aspect of brachium and crater; (1) details of crater fringe.
- H. *A. acaciae*, lateral aspect of brachium (shape and depth of crater indicated by dashes), showing association with anterior spiracle. The basal portion of the canella is also shown.
- I. *A. acaciae*, dorsal spine and ducts.
- J. *A. angulata*, marginal duplex duct cluster; (1) terminal aspect; (2) lateral aspect.
- K. *A. melaleucaae*, marginal duct cluster; (1) terminal aspect; (2) lateral aspect, showing the type of ducts composing this form of duplex cluster.
- L. *A. melaleucaae*, dorsal spine and ducts.
- M. *A. angulata*, dorsal spine and ducts.
- N. *A. australis*, lateral aspect of brachium and crater; (1) details of crater fringe.
- O. *A. acaciae*, internal termination of spermatozoid duct.
- P. *A. angulata*, structure of dorsal duct.
- Q. *A. acaciae*, marginal duct cluster.
- R. *A. australis*, anterior spiracle.
- S. *A. angulata*, anterior spiracle.
- T. *A. melaleucaae*, anterior spiracle.
- U. *A. angulata*, lateral aspect of marginal nuclear duct.
- V. *A. acaciae*, lateral aspect of marginal nuclear duct.
- W. *A. angulata*, structure of ventral duct.
- X. *A. melaleucaae*, lateral aspect of individual ventral duct.
- Y. *A. melaleucaae*, posterior spiracle.

Comparable figures not necessarily to the same scale of magnification.

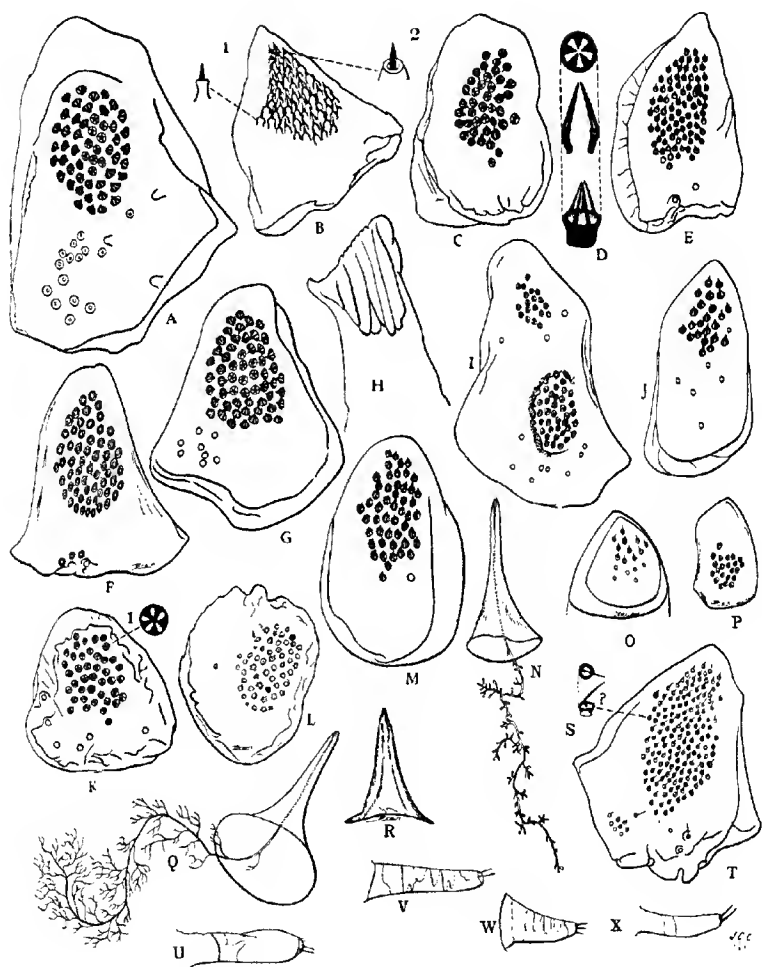


EXPLANATION OF PLATE XX.

Tachardina and *Afrotachardina*.

- A. *A. longisetosa*, brachial plate.
- B. *T. affluens*, brachial plate; (1) and (2) apparent structures of setae (?).
- C. *T. ternata*, brachial plate.
- D. *T. actinella*, diagrammatic figures, showing apparent structure of typical pseudospine.
- E. *T. actinella*, brachial plate.
- F. *T. decorella* (Mask.), Brain, brachial plate (after Brain). This is not true *decorella*.
- G. *A. brachysetosa*, brachial plate.
- H. *A. brachysetosa*, lateral aspect of brachium, showing "depth" to which chitinisation of brachial plate extends.
- I. *T. aurantiaca*, brachial plate.
- J. *T. lobata*, brachial plate.
- K. *T. decorella*, brachial plate; (1) individual pseudospine, showing apparent loculi.
- L. *T. harroo*, brachial plate (after Brain).
- M. *T. theae*, brachial plate.
- N. *A. brachysetosa*, dorsal spine and ducts.
- O. *T. minuta*, brachial plate (after Morrison).
- P. *T. minor*, brachial plate (after Brain).
- Q. *T. lobata*, dorsal spine and ducts.
- R. *T. decorella* (Mask.), Brain, dorsal spine (after Brain). This is not true *decorella*.
- S. *T. albida*, apparent structure of pseudospines in this species.
- T. *T. albida*, brachial plate.
- U. *T. lobata*, antenna.
- V. *T. actinella*, antenna.
- W. *T. albida*, antenna.
- X. *T. theae*, antenna.

All figures of brachial plates, excepting those taken from other authors, are upon the same scale. Antennae to the same scale. Figures Q and X to the same scale.



ENTOMOLOGICAL NOTES FROM TARANTO (ITALY) WITH REFERENCES TO FAENZA, DURING 1917 AND 1918.

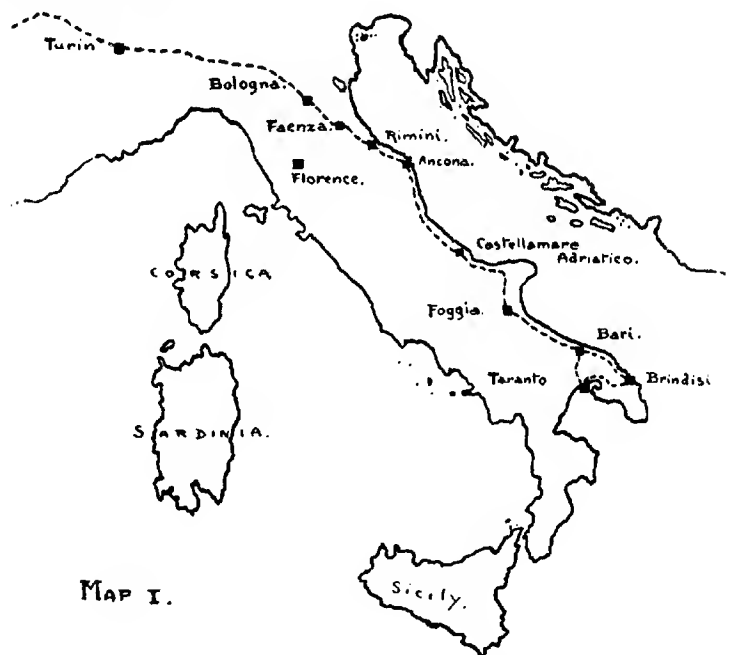
By E. HARGREAVES, A.R.C.S., D.I.C., F.E.S.

These notes record some observations that were made during the anti-malarial campaign carried out by the British Army at Cimino, Taranto.

Over 30 species of blood-sucking insects were collected, but by far the most important are the Anopheline mosquitos, and these will be dealt with first.

Anopheles maculipennis, Mg.

This is the most prevalent species, but the work carried out caused an enormous reduction. All the camp sleeping quarters were inspected each week, and during November only one Anopheline was caught, the general influx ceasing about the middle of October.



The hibernating females seem to show a preference for cow-sheds and donkey stables rather than for horse stables, fowl-houses and rooms containing pigs or goats. In one instance a large catch was obtained from an empty stone dwelling partly in ruins, which may have been due to the numerous people frequenting the place. During the month of January, some of the hibernating females had empty but distended abdomens, probably indicating that they had recently oviposited.

Emergence in numbers begins about the middle of May. The first specimens emerged from collected material on 26th April, and the first adult male was caught in the field on 6th May.

In the laboratory, eggs were deposited in January to the number of about 140 per female, which was observed to be the general content of the ovaries. Ten to thirteen days elapsed before hatching. As in the case of *Culex*, the eggs are nearly white when first deposited, darkening the following day. Oviposition took place at night, and in many cases the adult was unable to leave the water.

Water containing growths of *Spirogyra* are favoured by the female for oviposition. In one case a stream was heavily infested with Anopheline larvae, which lived among the small masses of *Spirogyra*, but when the stream was cleared of these growths no further infestation occurred. In only one instance was this mosquito observed to breed in water troughs, and never in wells. The larvae are, however, often found in seepage areas and in footprints containing water.

Adults have occasionally been caught in railway carriages during the journey between Taranto and Faenza, and this probably explains a case of malaria contracted at Castellamare Adriatico in 1917, as no Anophelines were found to breed in this district. (Map I.)

Anopheles bifurcatus, L.

This is fairly numerous in houses, but only three specimens were taken in the camp. It generally breeds in wells and troughs, seldom in open ditches, the last having been observed only during winter. Its flight is limited to houses in the vicinity. For this reason breeding-places are easily located.

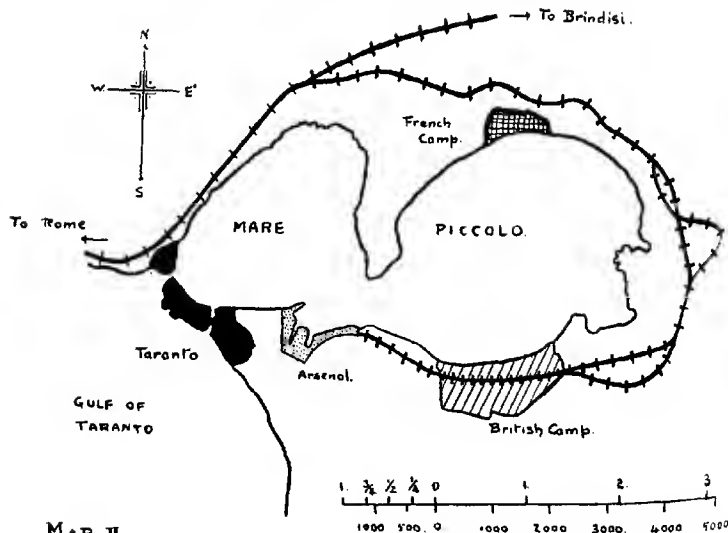
The larvae are able to withstand a low temperature, and were quite healthy after being frozen over for a few days.

Emergence begins in numbers in March and continues until the end of November. It appears to go on slowly during the winter.

Cannibalism in the case of the larvae is most marked, one individual seizing another, generally near the posterior end, but occasionally about the middle of the body, and practically the whole of it is eaten with the exception of the head.

Anopheles superpictus, Grassi.

Only one specimen was encountered, on 5th September. It was stated by the French authorities, who were in occupation of the opposite (north) side of the Mare



MAP II.

Piccolo, that this species was quite common there during August and September. The railway leading into the British camp circumscribes the Mare Piccolo, and there is little doubt that the above specimen entered by this means, as the prevalent wind is from the south, and the water at this point is more than two miles across. (Map II, scale in miles and metres.)

OTHER MOSQUITOS.

Culex pipiens, L.

This mosquito is exceedingly common and was found to breed throughout the whole year in almost any kind of water, except sea water, including sullage water that contained some cresol and that had been regularly treated with chloride of lime.

A large amount of work in ditch maintenance was caused by crabs, which burrowed into the beds and sides of ditches until they reached water. These burrows have been found to contain larvae of *Culex* and are possible breeding-places for *Anopheles*. They were controlled by squirting in a mixture of 1 part cresol to 5 parts of heavy oil by means of a syringe, the holes being afterwards plugged with earth.

Theobaldia longiareolata, Mcq.

This is numerous and breeds under similar conditions to *Culex pipiens*. It is active the whole year, and most numerous in September, October and November.

Larvae have been found with their siphons frozen in ice, but they were quite lively at the time, and later seemed no worse for the experience.

In some larvae there was a bulbous expansion of each of the main longitudinal tracheae immediately anterior to the base of the siphon. These all proved to be males.

Cannibalism is rife, and the larvae also eat those of *Culex* and *Anopheles*.

It may be worthy of mention that an adult female was kept alive for 90 days from emergence, the food supplied being the fruit of apple and banana.

Theobaldia annulata, Schr.

This is rarely met with except during the early months of the year, and then only in small numbers. The adults are more numerous on the north side of the Mare Piccolo, and are active throughout the year.

Less common Culicine mosquitos were *Culex hortensis*, Fic., *Culex univittatus*, Theo., *Culex laticinctus*, Edw., *Uranotaenia unguiculata*, Edw., *Theobaldia fumipennis*, Steph., *Aedes caspius*, Pall., *A. detritus*, Hal., *A. rusticus*, Rossi, *A. vexans*, Mg., *A. pulchritarsis*, Rond. (rare, found only in Faenza), and *A. argenteus*, Poir. (Five specimens caught in early October).

OTHER INSECTS.

Psychodidae.

Phlebotomus papatasi was very abundant around Taranto, but not in Faenza.

Chironomidae.

During the very hot weather of July and August a species of *Ceratopogon* appeared in enormous numbers and attacked any exposed parts of the body. An ointment was made up as a repellent consisting of: eucalyptus ointment B.P. 10 parts, vaseline 90 parts, 10 minims each of spirits of camphor and citronella oil being added to each ounce.

This proved effective also against mosquitos, but it apparently attracted flies.

A species of *Culicoides* was occasionally met with.

Simuliidae.

Simulium was present in small numbers, but drainage work destroyed the breeding-places of these flies.

Tabanidae.

This family was exceedingly numerous during the summer and proved a great source of annoyance, especially members of the genus *Haematopota*. They were incidentally dealt with by the anti-malarial measures. The following species were taken :—

<i>Tabanus ater</i> , Rossi.	<i>Tabanus kervillei</i> , Surc.†
<i>T. bifarius</i> , Lw.	<i>T. solstitialis</i> , Schin.†
<i>T. nemoralis</i> , Mg.	<i>T. spodopterus</i> , Mg.†
<i>T. autumnalis</i> , L.*	<i>Haematopota pluvialis</i> , L.
<i>T. cordiger</i> , Mg.*	<i>H. italica</i> , Mg.*
<i>T. tergestinus</i> , Egg.*	<i>Chrysops perspicillaris</i> , Lw.†
<i>T. bromius</i> , L.†	<i>Pangonia variegata</i> , F.
<i>T. fulvus</i> , Mg.†	

Muscidae.

Stomoxys calcitrans and *Lyperosia irritans* occur in small numbers.

Widespread measures were taken against *Musca domestica* over the territory included within a radius of one and a half miles outside the camp. The majority of houses with their stables, pigsties, goat-yards, etc., were filthy, and a town refuse dump was situated not far from the camp. These provided ideal conditions for fly breeding. Adults occur throughout the winter and are active on warm days. It may be noted that house-flies bred in enormous numbers in the crust of septic tanks.

Only one specimen of *Oestrus ovis* was seen.

Aquatic Insects.

Odonata.	Dytiscidae.
<i>Aeschna mixta</i> .	<i>Agabus conspersus</i> .
<i>Calopteryx splendens</i> .†	<i>Agabus nebulosus</i> .
<i>Orthetrum brunneum</i> .†	<i>Agabus bipustulatus</i> .*
	<i>Acilius sulcatus</i> .†
	<i>Colymbetes fuscus</i> .*
	<i>Dytiscus marginalis</i> .*
	<i>Eretes strictus</i> .†
	<i>Hyphydrus aubei</i> .
	<i>Noterus crassicornis</i> .
	Gyrinidae.
	<i>Gyrinus urinator</i> .
	Hydrophilidae.
	<i>Berosus affinis</i> .
	<i>Helophorus aquaticus</i> .
	<i>Hydrophilus aterrimus</i> .

Representatives of all these classes were exceedingly numerous, and they must have played some part in control of mosquitos. From observations in the laboratory

* Taken also in Faenza.

† Taken in Faenza only.

the most rapacious of the aquatic insects (adults) was *Colymbetes fuscus*, which devoured larvae and pupae of all kinds at the rate of 20 per day.

A Hydrophilid larva consumed all the larvae and pupae given to it unless small fish were present, which it preferred.

Large numbers of small fish, which ate mosquito larvae greedily, came up small streams from the sea at certain times of the year and kept them free of mosquito larvae during those periods.

Hydrometra stagnorum was observed with the tip of the rostrum embedded in the body of an adult Chironomid, and it is possible that it may similarly attack mosquitos during emergence or oviposition.

In connection with mosquitos, a very noticeable feature is the presence of the small immature stages of red mites attached to all the active instars of Anopheline mosquitos. When the larvae moult or pupate, the mites attach themselves to the new instar. They are rarely seen on Culicines. In the adult they are arranged in rings around the junctions of the abdominal segments, and are more often present, as well as being in larger numbers, on the male than the female.

A specimen of the Coelenterate, *Hydra*, was encountered that had ingested a complete *Theobaldia* larva of the first or second instar.

In some areas the breeding of mosquitos was limited to particular ditches, the water containing aquatic vegetation in addition to other insect larvae and mites. In adjacent ditches mosquito larvae were very rarely seen, and then never Anophelines; there were no other insect larvae, only a small amount of vegetation, and few mites.

Samples of water from the latter were analysed with the following result:—

Chlorine content	674.5 parts per 100,000.
As sodium chloride	1112.9 " " "

This is more than one-third the quantity contained in British sea-water.

Total solids	1194.0 parts per 100,000.
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Occupied houses between the camp and the mosquito breeding areas, especially when including a building for cattle, formed good collecting places for mosquitos. These were inspected regularly, and the mosquitos caught. When only a few Anophelines were taken in the camp, 50–100 were caught week after week in two such houses situated at distances of $\frac{3}{4}$ mile and 1 mile respectively from the edge of the camp, while the breeding area was $1\frac{1}{2}$ miles beyond the houses. The mosquitos must therefore have flown at least $1\frac{1}{2}$ miles to the houses and nearly $2\frac{1}{2}$ to the camp, as conditions were such that there was no breeding of Anopheline mosquitos within that radius of the camp. Other observers have found them to travel a much greater distance.

Drip-cans for the automatic oiling of running water were very effective, and proved a great labour-saving device. Both heavy and light oils were used, and a sufficient drip (20 to 30 drops per minute) was maintained for a week with four to five gallons.

During the dry season, four-gallon petrol tins about one-third full of water, with reeds and *Spirogyra*, were partially buried in the ground, arranged in a zone at a distance of a quarter of a mile from the camp limits, with the idea of inducing Anophelines to deposit their eggs. A sufficient number were in use to allow weekly change and to retain those brought in for a period of three weeks for observation.

Numerous eggs of *Theobaldia* and *Culex* were so taken, but never *Anopheles*. It is possible that earthenware containers would have given better results.

Small pits dug in the ground where the water level was suitable were quite successful. As they became infested, they were filled in and others made.

DEGREE OF INFECTION OF ANOPHELINES.

During the season (from 15th April 1918 to 3rd December 1918) 949 Anopheline mosquitos were dissected, of which 193 were *A. bifurcatus*, and the stomachs and salivary glands examined for malarial parasites. The results are arranged in weekly totals, beginning with the week ending 22nd April.

Date.	<i>Anopheles maculipennis.</i>	Infected		<i>Anopheles bifurcatus.</i>	Infected	
		Stomach.	Glands.		Stomach.	Glands.
April 22	6	—	—	—	—	—
29	12	—	—	6	—	—
May 6	—	—	—	5	—	—
13	6	—	—	13	—	—
20	—	—	—	—	—	—
27	12	—	—	12	—	—
June 3	7	—	—	42	—	—
10	11	—	—	—	—	—
17	23	—	—	34	—	—
24	52	2	1	9	1	1
July 1	67	4	2	8	—	1
8	25	—	—	14	1	—
15	49	4	—	—	—	—
22	24	2	—	—	—	—
29	45	2	—	2	—	—
August 5	72	7	—	2	—	—
12	44	3	1	4	—	—
19	59	7	—	1	—	—
26	35	6	—	4	—	—
September 2	31	5	—	6	—	—
9	24	5	1	5	—	—
16	16	1	—	2	1	—
23	29	2	—	3	—	—
30	33	3	1	—	—	—
October 7	24	3	1	—	—	—
14	18	—	1	—	—	—
21	9	1	—	5	—	—
28	5	1	—	7	1	—
November 4	5	—	—	2	—	—
11	1	—	—	—	—	—
18	1	1	—	1	—	—
25	3	—	—	4	1	—
December 3	8	—	—	2	—	—
TOTALS	756	59	8	193	5	2

Summary of results of dissections :—

<i>A. maculipennis.</i>		<i>A. bifurcatus.</i>	
Stomach with cysts.	Glands infected.	Stomach with cysts.	Glands infected.
7·81 per cent.	1·06 per cent.	2·59 per cent.	1·03 per cent.

EXPERIMENTS.

1. To ascertain what sizes of mesh for wire gauze and muslin were proof against the local species of mosquitos. It was found that the minimum for wire gauze was fourteen, and for muslin thirteen, meshes to the inch each way.

2. To deal with wells where Anophelines are breeding in such a way as not to pollute the water. A solution of copper sulphate in water from an infested well was made up at the following strengths: Percentages 0.1, 0.05, 0.025, 0.01, 0.008, 0.006, 0.005, 0.004, 0.003, 0.002, 0.001. Controls contained simple well-water.

Ten larvae of *Anopheles bifurcatus* from the well, of all sizes from very young to almost full-grown, were placed in a dish of each solution and each control. After three days all in the controls were still alive, but all in the solutions were dead with the exception of those of the strengths 0.004 per cent. to 0.001 per cent. The 0.006 per cent. and 0.005 per cent. solutions were again tried. In the former all were dead on the second day; in the latter all on the third day. The stronger solutions of 0.1 per cent. and 0.05 per cent. were longer in causing death than the 0.025 per cent. and 0.01 per cent.

From these results it would appear that a 0.005 per cent. solution is the optimum strength. It is probable that waters of different compositions would require slightly different amounts of copper sulphate. Opinion seems to vary as to the amount of copper sulphate which may be used in drinking water without injury to health. Unfortunately, the owners of wells would not consent to the use of copper sulphate.

3. In tests of the action of bacilli, it was noticed in the case of larvae being reared in the laboratory that a film of bacillary growth appeared on the surface of the water, in some cases overnight, and all the larvae were dead within three days afterwards. The film consisted mainly of the hay bacillus. Cultures of this were made for the infection of other waters, but without success.

4. It has been stated that the "leaves" of the "prickly pear" are of use as a larvicide against mosquitos. As this plant was common in the district, tests were made with it. When Anopheline and Culicine larvae were placed in an infusion made at a strength of 5 per cent. by weight of fresh leaf, the larvae thrived and developed more rapidly than those in the controls.

A 5 per cent. decoction was then made by shredding the tissue and allowing it to soak overnight. The liquid was decanted, and the following strengths of this made up with water: 100 per cent., 50 per cent., 25 per cent., 12.5 per cent.

In the three higher percentages the larvae could only wriggle without making any progress, and as they were unable to reach the surface were asphyxiated.

In the 12.5 per cent. solution, they could make some progress, with apparent exertion, and *Culex* larvae died the first day, *Theobaldia* the second, and *Anopheles* the third.

In conclusion, my thanks are due to Dr. G. A. K. Marshall, C.M.G., F.R.S., Director of the Imperial Bureau of Entomology, and the specialists of the British Museum (Natural History), who kindly carried out the determination of the insects found.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June 1923, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. G. ARNOLD :—10 Tabanidae, 162 other Diptera, 46 Hymenoptera, 78 Coleoptera, 17 Rhynchota, and 27 Orthoptera ; from Rhodesia.

Mr. T. V. RAMAKRISHNA AYYAR, Assistant Entomologist :—24 Mutillid Hymenoptera, and 2 Coleoptera ; from South India.

Mr. H. A. BALLOU, Entomologist, Imperial Department of Agriculture :—2 Chalcididae, 5 Lepidoptera, and 6 pupae ; from Barbados.

Mr. P. J. BARRAUD :—226 Coleoptera and 3 larvae ; from Punjab, India.

Mr. G. E. BODKIN, Agricultural Entomologist, Department of Agriculture and Fisheries :—19 Diptera, 28 Hymenoptera, 67 Coleoptera, 6 Lepidoptera, 14 Rhynchota, and 3 Orthoptera ; from Palestine.

Dr. G. BONDAR :—55 Coleoptera and examples of damage done to cacao ; from Brazil.

Dr. C. K. BRAIN :—94 Rhynchota ; from South Africa.

Dr. H. BRAUNS :—2 Tabanidae, 43 other Diptera, and 52 Coleoptera ; from Cape Colony.

Mr. H. E. BOX :—32 Diptera and 2 pupa cases, 10 Hymenoptera, 24 Coleoptera, 2 Lepidopterous pupa cases, and 1 species of Coccidae ; from British Guiana.

Mr. E. H. BRYAN, Junr. :—6 *Chrysops*, 124 other Diptera, and 4 pupa cases ; from Hawaii.

Dr. P. A. BUXTON :—106 Culicidae, 3 Culicid preparations, 140 Tabanidae, 4 Psychodidae, 8 Simuliidae, 258 other Diptera, 700 Formicidae, 98 Chalcididae, 471 other Hymenoptera, 94 Coleoptera, 23 Lepidoptera, 2 species of Coccidae, 42 other Rhynchota, 144 Orthoptera, 32 Anoplura, 131 Mallophaga, 2 Ticks, 100 Mites, 19 Spiders, and 47 Scorpions ; from Palestine.

Dr. M. CAMERON :—183 Curculionidae ; from Dehra Dun, India.

Mr. L. D. CLEARE, Junr., Government Economic Biologist :—3 species of Coccidae ; from British Guiana.

Mr. G. H. CORBETT, Government Entomologist :—1 species of Coccidae, 2 species of Aleurodidae, and 10 other Rhynchota ; from the Federated Malay States.

Dr. A. CROS :—93 Orthoptera ; from Algeria.

Mr. M. T. DAWE :—71 Coleoptera and 7 larvae, and examples of palm kernels attacked by them ; from Sierra Leone.

Colonel I. R. DODD :—5 *Haematopota*, 2 *Tabanus*, 1 *Auchmeromyia*, and 1 *Auchmeromyia* larva ; from Northern Rhodesia.

ENTOMOLOGISKA RIKSMUSEETS, STOCKHOLM :—74 Orthoptera ; from various localities.

Mr. W. W. FROGGATT :—2 Psychodidae, 17 other Diptera, 58 Hymenoptera, 25 Coleoptera, 4 Lepidoptera, 2 species of Aphididae, 25 other Rhynchota, 4 Thrips, and 4 Mantispids ; from New South Wales, Australia.

Mr. F. D. GOLDING :—32 Diptera, 12 Hymenoptera, 74 Coleoptera, 22 Lepidoptera, 39 Rhynchota, and 4 Orthoptera ; from South Nigeria.

Dr. P. v. d. GOOT :—16 Coleoptera, 13 Moths, and 6 Capsid Bugs ; from Java.

Mr. C. C. GOWDEY, Government Entomologist :—9 Culicidae, 26 other Diptera, 8 Hymenoptera, 23 Coleoptera, 17 Lepidoptera, 3 species of Coccidae, 15 other Rhynchota, 2 Orthoptera, 39 Termites, 2 Odonata, 2 Psocids, and 6 Mites ; from Jamaica.

Mr. G. H. HARDY :—24 Diptera, 11 Dipterous pupa cases, and 1 Chalcid ; from Queensland.

Mr. E. HARGREAVES :—4 Tabanidae and 6 Coleoptera ; from Italy.

Mr. H. HARGREAVES, Government Entomologist :—3 Siphonaptera, 49 Diptera, 108 Hymenoptera, 322 Coleoptera, 36 Lepidoptera, 1 species of Aleurodidae, 20 species of Coccidae, 18 other Rhynchota, 3 Orthoptera, 270 Thysanoptera, 10 Ticks, and 1 Spider ; from Uganda.

Mr. G. F. HILL :—38 Culicidae, 193 other Diptera, and 35 early stages ; from North Queensland.

Major R. W. F. HINGSTON :—53 Gryllidae ; from United Provinces, India.

Mr. G. V. HUDSON :—92 Hymenoptera and 64 Coleoptera ; from New Zealand.

Mr. M. AFZAL HUSSAIN, Government Entomologist :—360 Orthoptera, and 25 Thrips ; from Punjab, India.

Mr. R. W. JACK, Chief Entomologist, Department of Agriculture :—4 *Stomoxys*, 28 other Diptera, and 150 Parasitic Hymenoptera ; from Southern Rhodesia.

Mr. A. H. LEES :—1 species of Aleurodidae attacking Oak trees ; from California.

Mr. S. F. LIGHT :—4 Diptera, 4 Hymenoptera, 960 Coleoptera, and 14 Rhynchota ; from China.

Dr. L. LLOYD :—3 Bombyliidae and 3 pupa cases, and some pupa cases of *Glossina tachinoides*, Westw., parasitised by Bombyliidae ; from Northern Nigeria.

Dr. R. E. McCONNELL :—61 Culicidae, 10 Tabanidae, 3 other Diptera, and 5 Dipterous larvae ; from Uganda.

Dr. J. W. SCOTT MACFIE :—1 Snake skin ; from the Gold Coast.

Mr. G. A. MAVROMOUSTAKIS :—19 Forficulidae ; from Cyprus.

MINISTRY OF AGRICULTURE, CAIRO :—347 Orthoptera ; from Egypt.

Prof. S. MOKRZECKI :—5 Diptera ; from Poland.

Mr. J. C. MOULTON, Director, Raffles Museum :—4 Coleoptera and a large number of Collembola ; from Singapore.

Mr. F. MUIR :—9 Curculionidae ; from Hawaii.

Mr. N. A. MURRAY :—2 Hymenoptera, 46 Coleoptera, 3 Rhynchota, 10 Orthoptera, 2 Mantispids, 4 Spiders, 1 Scorpion, 2 Lizards, and 1 small Snake ; from Western Australia.

MUSEUM NATIONAL D'HISTOIRE NATURELLE, PARIS :—449 Orthoptera ; from various localities.

NATAL MUSEUM :—78 Coleoptera and 46 Rhynchota ; from South Africa.

Mr. A. W. J. POMEROY, Government Entomologist :—1,172 Tachinidae and 69 pupa cases, 18 other Diptera, 104 Hymenoptera, 27 Coleoptera, 33 Lepidoptera, 172 Rhynchota, 4 Orthoptera, and 2 Trichoptera ; from Southern Nigeria.

Mr. H. W. SIMMONDS, Government Entomologist :—14 Diptera, 11 Hymenoptera, 44 Coleoptera, 48 Lepidoptera, and 5 Rhynchota ; from Fiji Islands.

Mr. A. THÉRY, Institut Scientifique Chérifien, Rabat :—146 Orthoptera ; from French Morocco.

Dr. R. J. TILLYARD, Chief of the Biological Department, Cawthron Institute of Scientific Research :—1 species of Aphididae ; from New Zealand.

Mr. R. VEITCH :—5 Hymenoptera, 4 Coleoptera, 10 Lepidoptera, and 7 Rhynchota ; from Fiji Islands.

Mr. G. N. WOLCOTT :—6 Hymenoptera, 46 Coleoptera, 2 Lepidoptera, and 4 Rhynchota ; from Porto Rico.

WELLCOME TROPICAL RESEARCH LABORATORY, KHARTOUM :—136 Coleoptera ; from British Sudan.

Mr. R. C. WOOD :—1,615 Coleoptera ; from Nyasaland.

AN APPARATUS FOR TESTING THE TOXIC VALUES OF CONTACT INSECTICIDES UNDER CONTROLLED CONDITIONS.

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and

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Rothamsted Experimental Station.
(PLATES XXI-XXII.)

Introduction.

The apparatus described in this paper was constructed for the purpose of comparing quantitatively the lethal properties of contact insecticides. It was designed on the assumption that if successive numbers of similar insects are placed upon a plane surface of constant area and sprayed with a spray evenly distributed over that area under constant conditions as regards the amount of fluid, pressure of spraying, spreading, wetting and adhering properties of the fluid, for the same concentration of toxic substance, the amounts of poison received by each insect will always be equal. On varying any one of these factors any difference in the effect observed on the insects will be directly due to this variation.

For the immediate purposes of our investigation the factors varied were the poison and its concentration, so that provided that the foregoing assumption is correct, the proportion of dead to numbers sprayed will at each concentration give a measure of the toxicity at that concentration. If a number of chemical substances are tested at different strengths, curves can be plotted indicating how toxicity varies with the concentration and chemical constitution.

From some suitable point upon each of these curves a direct comparison of toxicity between the chemical compounds can be made. Statistically the 50 per cent. death-point, that is the concentration of poison which kills 50 per cent. of the insects sprayed, is the best. If, for example, the concentration of a standard poison such as nicotine giving a 50 per cent. mortality is known, the ratio of this amount to the amount of another substance giving the same mortality may be regarded as an insecticidal index for that substance, while if the curves are continued from their lower to their upper limits, indications will be obtained of the strengths that the insects can sustain without injury and of those required to kill 100 per cent.

Description of Apparatus.

The parts of the apparatus can be grouped as follows:—

- (1). The arrangements for supplying air at a constant known pressure.
- (2). A glass jar and means of levelling both its wooden cover and a small glass dish inside the jar.
- (3). An arrangement for holding and adjusting the spray nozzle on the wooden cover of the jar.

The general lay-out of the apparatus is shown in Plate xxi, fig. A. Air is supplied from a cylinder of compressed air (1). When the cylinder is full this is at a pressure of about 120 atmospheres, but by means of a valve (2) it is released at any desired pressure, the pressure being regulated by a thumb-screw (3). The pressures within the cylinder and of the issuing air are indicated by dial gauges (4).

To obtain a more accurate indication of the pressure of the air, a Y-piece is inserted in the tube between the cylinder and the nozzle, one arm of which is connected to a mercury manometer (5) graduated to indicate pounds per square inch, and the other arm is connected to the nozzle. Between the cylinder and the Y-piece a filter (37) is

inserted in the air tube, composed of a glass tube containing copper gauze and cotton-wool. This was found to be necessary owing to the amount of dust in the air, which gradually choked up the small outlet holes of the nozzle.

The air supply to the nozzle is turned on and off by means of a tap above the valve (6). The usual size of compressed air cylinder used holds 100 cubic feet of air.

The glass jar (Plate xxi, figs. A, B-7) in which the spraying is carried out has an internal depth of 44 cm. and an internal diameter of 19.5 cm.

This jar stands on a levelling platform (Plate xxi, figs. B, C-10), resting on three ivory points (8), which are fixed on small plates (9) arranged to slide on the arms of the levelling platform, to which they can be locked in any position. The platform is levelled by means of three screws (11), the points of the screws resting on small blocks on the table.

Within the jar is a smaller levelling platform (Plates xxi, xxii, figs. B, D-12), which supports in a similar manner a small glass dish (13) in which the insects to be sprayed are placed. In addition, this platform bears screws with ivory tips (14), at the outer ends of the arms, by means of which the platform is held in a central position in the jar. Two of these screws can be locked so that after being removed from the jar, the platform can be returned to the same position.

By means of marks on the jar and on the two levelling platforms, they can always be returned to the same position after removal.

The cover of the glass jar (Plates xxi, xxii, figs. B, E-15) is of mahogany, and rests on the top of the jar. It is held in position by three blocks resting against the inside of the jar (16). One of these blocks is fixed, while the other two are movable, and can be locked in any position by screws (17). By means of marks on the cover and on the jar, the cover can always be replaced in the same position. A large hole is cut in the cover, within which is fastened the arrangement for holding and adjusting the nozzle.

The nozzle (Plate xxii, figs. E, F-18)* is composed of two tubes; one, the air tube (text-fig. 1, B), has one end enlarged for connecting with the air supply, and the other end is closed by a screw (A), which can be removed to clean the tube. The outlet for the air is through two small holes (C) close together on the lower side of the tube near its closed end. The other, the liquid tube (E), is bent at right angles, and one arm is attached along the lower side of the air tube, so that the end comes opposite the two outlet holes in that tube. This end of the liquid tube is of smaller internal diameter than the remainder. The other arm of the liquid tube bends down at right angles from the air tube.

Part of the length for which the air and liquid tubes are joined is covered by a short length of wider tube (Plate xxii, fig. F-21), so that the nozzle can be held and turned in a clamp. The clamp (22) is attached by a screw to a small block (23), which is again attached by a screw to a small plate (Plate xxii, figs. E, F-24). By adjusting the block and clamp, the nozzle can be moved forward and back, turned over either way, tilted up or down, and turned to either side.

To the upper side of the air tube is attached a gallows (Plate xxii, figs. E, F-25), from which a plummet (26) is suspended over a scale of squared paper on the cover, by means of which it is possible to tell whether the nozzle is correctly adjusted, after the correct position has once been found. The thread holding the weight passes through a hole at the end of the gallows and is attached to a slide on the arm, so that the height of the weight can be regulated.

The small plate to which the clamp is attached bears two small holes (27) which connect with two points (28) on a larger intermediate plate (29), and the small plate

* This nozzle was designed for us by Mr. Leopold Ward, 2-3, Duke Street, S.W. 1. The apparatus was constructed to our design by Messrs. Pellant, Harpenden.

is then held in position by two clamps, each tightened by a screw (30). The object of having this small removable plate is in order that the nozzle may be conveniently removed for cleaning and then replaced without losing its adjustment. This is only necessary very occasionally, as the liquid tube can be cleaned by spraying water through from the reservoir.

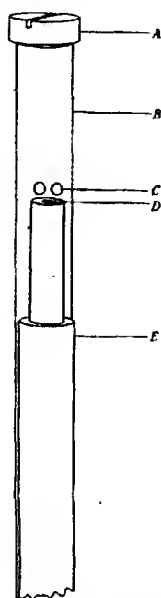


Fig. 1. Detail of nozzle: A, screw to allow of cleaning air tube; B, air tube; C, air outlet holes; D, liquid outlet; E, liquid tube.

The intermediate plate bears at one side a ball (Plate xxii, fig. r-31) which fits into a socket (32) on the basal plate (36) and can be locked by two screws. These two plates are further joined by two screws (33) at the opposite side to the ball joint. These screws are slightly curved and are attached to the basal plate, passing through slots in the intermediate plate, the position of the intermediate plate being altered by two milled nuts on each screw (38a, b). This arrangement of screws and a ball and socket joint is perhaps an unnecessary refinement, but gives a means of making small adjustments with greater accuracy than by the other methods described.

The free arm of the liquid tube of the nozzle passes through holes in the intermediate and basal plates. The liquid to be sprayed is contained in a small glass tube (Plate xxii, fig. r-34) which is held in a clip (35) so that the liquid tube of the nozzle reaches just to the bottom, the clip being fastened over the air tube.

The current of air blowing out through the two small outlet holes in the air tube across the open end of the liquid tube causes a partial vacuum, which draws the spray fluid from the reservoir and throws it out in the form of a very fine spray.

In Plate xxi, figs. A and B, the internal platform is shown resting on a glass plate † which is raised above the bottom of the jar on a glass tripod. The reasons for this are set out later, but, in brief, it renders spraying more accurate and easy. With this modification the distance from the nozzle to the dish is about 36 cm.

† This plate has a central perforation 2 cm. in diameter by means of which it can be readily placed in position.

A considerable experience with this apparatus has shown that it might be simplified in certain details for less critical work without any material loss of accuracy. The intermediate plate with its ball and socket joint and the two screws for fine adjustments might be omitted, and the small upper plate clamped directly on the basal plate. As there is a dial gauge attached to the cylinder, which can be read with moderate accuracy down to 10 lb., the mercury manometer is unnecessary for any but the most careful work.

The apparatus is set up in the following way:—The spray nozzle is connected to the air cylinder as shown in Plate xxi, fig. A, and by a preliminary trial the valve is adjusted to give the desired pressure in the gauge and manometer (in our case 15 lb. per square inch). The glass jar is placed upon the ivory points of the large external platform and adjusted to a central position; the top is then put on with the arrow marked on the mahogany cover just over the arrow marked on the lip of the jar. It is then fixed in position by the sliding blocks on the lid, until a minimum of lateral movement is possible, and levelled by means of the milled-head screws on the platform.

The cover is then removed and the internal platform is placed in the jar, centred by means of the ivory-tipped screws, and levelled. A glass disc 5 cm. in diameter is then placed centrally on this platform, in the position which will be occupied by the dish containing the insects to be tested (Plates xxi, xxii, figs. B, D-13).

The mahogany lid is replaced, the spray nozzle placed in position and the orifice brought perpendicularly over the centre of the disc, as indicated by a plummet let down into the jar.

The lid is removed and a circular glass plate of diameter 18.5 cm. (preferably with a central perforation to allow of easy manipulation) is lowered into the jar and placed with its centre over the centre of the disc. Small quantities of water or dilute saponin solution are sprayed over the glass plate and the position of the nozzle adjusted until the spray has an even distribution about the smaller disc underneath. For the final adjustments we placed a second small disc of diameter 5 cm. on the glass plate so as just to cover the one on the platform. The disposition of the spray on the small disc could then be examined, as well as the distribution round the area marked out by it.

The position of the indicating plummet attached to the nozzle is noted on the slip of squared paper fixed on the mahogany top, and the nozzle screwed up tight in its position. The apparatus is now ready for calibration and for use.

Calibration of the Apparatus.

The calibration can be carried out as follows:—After ascertaining that the spray is evenly distributed, a previously weighed disc or dish of 5 cm. diameter is placed in position on the central platform; 1 c.c. of water or saponin solution is pipetted into the reservoir and sprayed under known pressure. A disc is only suitable for amounts of spray of about 0.1 gm. After spraying, the disc is placed in a covered weighed dish and re-weighed. For quantities larger than 0.1 gm. a small dish with upright sides, such as is actually employed in spraying insects, is used. After spraying it is carefully wiped on the outside with filter paper, covered with a watchglass and re-weighed.

The data of a number of sprayings obtained in this way are set out in Table I.

All spraying was done at a pressure of 15 lb. per square inch.

Series A sprayed on to a disc 5 cm. in diameter, no air-filter used, and spraying timed with a stop watch. Air-tube of nozzle found to be slightly choked with dust after spraying.

Series B, C, D, E, G, H and I sprayed on to a dish 5 cm. in diameter with perpendicular sides 1 cm. deep, air-filter used, and sprayed until reservoir empty.

In series A and B distance from nozzle to dish or disc was 43.5 cm.; in series C, D, E, G, H and I distance was 36 cm.

Series D sprayed after dismantling and re-erecting apparatus; series H after detaching nozzle, washing and replacing.

Series A, B, C, D and E sprayed with nozzle No. 1, G, H and I with nozzle No. 2.

Mean of D is slightly but significantly different from mean of C.

Mean of E is slightly but significantly different from mean of D.

There is no significant difference in variability in series E.

There is no significant difference in the means of series G, H and I.

In series A and B spraying was carried out with the platform at the bottom of the jar, 43.25 cm. from the nozzle, and in the former the operation was carefully timed on and off. Under these tedious conditions it was found possible to spray with a high degree of accuracy at this depth, but if a change is made to the method actually used when insects are being sprayed, the Probable Error of any single spraying rises from 0.84 per cent. (in A) to 3.7 per cent. (in B). This is due to the fact that near the bottom of the jar eddy-currents are formed, and the spray can be observed drifting across the surface of the disc, any slight change in working conditions apparently profoundly altering the degree of drift.

TABLE I.
Data relating to Weights of Spray falling on an Area 5 cm. in Diameter.

Series.	A	B	C	D	E	G	H	I
Pressure in cylinder.						20 atmos.	20-5 atmos.	110 atmos.
Weight of spray falling on disc or dish (gms.)								
	(1) 0.1016 -1003 -1022 -1014 -1038 (2) -1010 -1044 -1020 -1036 -1033	(1) 0.1331 -1200 -1192 -1344 -1330 (2) -1195 -1290 -1291 -1355 -1405	0.2629 -2773 -2723 -2709 -2633 -2596 -2759 -2725 -2670 -2744 -2684 -2687	0.2604 -2680 -2650 -2633 -2596 -2763 -2771 -2772 -2826	Dish No. 1. Jan. 6 0.2715 -2485 -2540 Mar. 2 -2763 -2771 Dish No. 2 Mar. 2 -2772 -2826	0.2515 -2470 -2523 -2485 -2540 -2522 -2480	0.2515 -2430 -2463 -2473 -2522 -2480	0.2425 -2472 -2500 -2522 -2509
Mean ...	(1) 0.10186 (2) 0.10286	(1) 0.1279 (2) 0.1307	0.27072	0.26326	0.2777	0.25066	0.24805	0.24856
Probable error of single spraying %	±0.84	±3.7	±1.06	±0.79	±0.96	±0.89		

In view of this the internal platform was raised, the depth from nozzle to dish being reduced to 36 cm. The remaining data apply to this condition. It was found that it was much easier to spray at this depth, and that without taking any tedious or undue precautions the accuracy was considerable, the P.E. of series C being about 1 per cent.

Series D was carried out to test the effect of dismantling. The apparatus was taken down and then rebuilt. The results obtained in this series agree very closely amongst themselves, but are significantly different from those in series C. This differ-

ence is, however, only slight, and only becomes appreciable owing to the close agreement of the individual sprayings in the same series. It would hardly have any considerable bearing in actual practice, because the variation in the individual resistance amongst the insects sprayed is far greater than this, and because it is unnecessary, once the instrument is assembled, to dismantle it entirely for considerable periods of time. These series indicate, however, that some care is necessary in centring the spray before use.

The sprayings in series E were carried out to test the stability of the instrument and to find out whether a change of dish had any effect on the accuracy of the results. Two sprayings were carried out on 6th January and four on 2nd March. On the latter date different dishes were used. Between these two periods a considerable number of practical spraying tests were carried out. An analysis of the results showed that there was no significant difference in the variability of the results.

The data in series G, H and I refer to a second spraying nozzle made of wider tubing. It was constructed to avoid clogging during practical tests. The distribution of the spray is hardly so even as with No. 1, and it appears to be somewhat less in amount over the same area.

An opportunity was taken during these tests to ascertain the effect of detaching the nozzle and the plate to which it is clamped from the intermediate plate. This was carried out, the nozzle washed and put back, and a further series of sprayings, set out in column H, was done. There is no significant difference in the results arising from this operation.

Series G, H and I indicate that the amount of air in the cylinder, provided that it is above the minimum pressure required to give 15 lb. per square inch, has no influence on the amount of spray delivered.

The following analysis of the data in series A, B, C, D, E of Table No. I was carried out by "Mathetes," a voluntary worker in the Statistical Department at Rothamsted, to whom we desire to express our best thanks.

"The data were tested by the use of "Student's" Tables* (1) as recommended by

Fisher.† Applying the formula $Z = \frac{\bar{x} - \bar{x}^1}{\sqrt{S(\bar{x} - \bar{x}^1)^2 + S^1(\bar{x}^1 - \bar{x})^2}} \sqrt{\frac{n n^1}{n + n^1}}$, where n, n^1 are the numbers of observations on the two occasions, \bar{x}, \bar{x}^1 the corresponding means, "Student's" Tables give the probability of obtaining by chance an algebraically less value of Z , whence can be deduced the probability of obtaining by chance a value numerically greater than that observed, as shown in the following table:—

TABLE II.

	Z	n ($=n+n^1-1$)	P	Probability of obtaining a larger value of Z by chance.
A ₁ , A ...	.424	9	.8667	.2666
B ₁ , B ₂ ...	.200	9	.7066	.5868
C, D ...	.866	16	.9977	.0046

There is thus no evidence of a significant difference between means of determinations done on different days under the same experimental conditions, so that A₁ may be pooled with A₂ and B₁ with B₂, for comparison with C as to the relative accuracy of the various methods of spraying, and the results of such a comparison are set out below. It should be noted, however, that there is a significant difference between

* "Student" (1917) Tables for estimating the Probability that the means of a unique sample of observations lies between $-\infty$ and any given distance of the Mean of the Population from which the Sample is drawn (Biom. xi, pp. 414-17).

† R. A. Fisher (1922). The goodness of fit of regression formulae and the distribution of regression coefficients. J. R. Stat. Soc. lxxxv, pp. 597-612.

C and D, so that experiments carried out after dismantling and resetting up the apparatus are not directly comparable, so far as the mean weight of spray is concerned, with those carried out before, although there is no significant difference in variability.

TABLE III.

	Mean gms.	S.D.	Coefficient of variation V.	P.E. of single observation (actual) milligrammes.	Percentage P.E.
A	.10236	.0012808	1.2513	±0.86	±0.84
B	.12933	.0070900	5.4821	±4.78	±3.70
C	.270725	.0042370	1.5651	±2.86	±1.06
D	.26326	.0030684	1.1655	±2.07	±0.79
E	.27778	.0039699	1.4292	±2.68	±0.96

It will be seen that B is much more variable than A or C, while C is very little worse than A, and having regard to the ease and speed with which determinations are carried out under the conditions obtaining in method C as compared with A, it is much to be preferred.

Series E closely resembles C, except that the mean weight of spray is significantly higher. There is no significant difference in variability, but the difference in mean weight points to the advisability of making control weighings after re-centring the apparatus."

The evenness of distribution of the spray was examined by spraying small quantities of Indian ink diluted with saponin solution on clean glass plates and on blotting paper.

These tests indicated that while the spray was by no means evenly distributed over the whole area covered by it, the spray thinning off rapidly towards the edges as might be expected, it was nevertheless fairly even over the small area in the centre which was actually used in the experiments, about 25 per cent. of the liquid sprayed actually falling on this area, as indicated in Table I.

Spraying Practice.

As the apparatus is intended to test contact insecticides, the most suitable test subjects are sucking insects. *Aphis rumicis* (apterous agamic females) in the adult stage have been chiefly used by us. The mode of operation is as follows:—

A number of these insects are placed upon a disc of flannel, held in position in the glass dish by three clips (Plate xxii, fig. 1). The slightly frayed surface of the flannel prevents the insects from moving too freely and so allows time for them to be sprayed before they can escape from the dish.

The dish is then placed in position in the jar, the required amount of the substance to be tested is placed in the small glass tube (Plate xxii, fig. F-34), and the air turned on from the cylinder.

After spraying, the disc of flannel is removed with the aphides upon it and placed with a supply of the food-plant in a large petri dish, which is then covered with fine cotton gauze stretched on an iron ring, the diameter of which is greater than that of the dish. The weight of the iron ring keeps the gauze in position and prevents it from being accidentally knocked off.

The dishes of sprayed insects are carried on trays to a shady, well-ventilated greenhouse, where they are kept for examination. A moderately warm, but damp, shady place is found most suitable for this purpose.

The aphides are examined and given fresh food after periods of one and two days. By prolonging the period of inspection the subsequent grouping of results is somewhat simplified, but as the effectiveness of an insecticide can generally be judged after two days, the result hardly compensates for the extra labour involved.

Those aphides which are unaffected by the spraying are usually found feeding on the leaves or walking on the dish or cover. Others are found lying on the flannel or on the bottom of the dish. They are all examined and their condition recorded as being in one or other of four categories:—

Alive.—Aphides apparently unaffected by the spray.

Slightly affected.—Aphides affected to a certain extent, but still able to move, and likely to recover.

Moribund.—Aphides considerably affected and only able to make slight aimless movements of the appendages.

Dead.—Aphides apparently dead.

By prolonging the inspection period these categories tend to simplify out into dead and alive; this, however, is attended by a certain amount of risk, as some of the insects may die from causes other than that due to the experiment. When further data are available it may be possible to give values to these groups based upon statistical analysis. The numbers of dead or alive can then be expressed in percentages of the numbers sprayed, or better, of the number of survivors in the controls.

The number of aphides sprayed at a time has been usually ten, a larger number increasing the difficulties of handling before, and of examination after, spraying. Spraying so small a number as this at each concentration enables one to separate out useless compounds from those that are worth further investigation.

For the final evaluation of the latter it is imperative to use larger numbers of insects for each concentration. This arises from the variations—which may be wide—in the individual resistance of the insects. As it is extremely difficult during examination to count, say, a hundred aphides moving about in an enclosed and comparatively small space, and to record with accuracy the results, and as when a large number are sprayed together some insects are likely to crawl over others and so prevent the even distribution of spray over the whole number, it has been our practice to make several repetitions of sprays at each concentration, using ten at a time.

The aphides used in these experiments are specially reared for the purpose and are all descended from a single fundatrix. The successive generations are raised on broad-bean plants in pots under muslin covers in a greenhouse. Each set of plants is infected from one plant of the previous set, a single apterous agamic female being placed on each plant. As all the aphides for a series of tests are taken from the same set of plants, they all belong to approximately the same generation. The aphides used for spraying were always adult apterous agamic females. By taking these precautions it was hoped to reduce the variation in resistance of the aphides to a minimum.

The removal of the aphides from the plants for spraying requires care to avoid injuring them in any way, as they only remove their stylets slowly from the tissues upon which they are feeding. It can, however, be safely accomplished by cutting off the parts of the plants infested, when it is found that after a short time the insects withdraw their stylets spontaneously and begin to wander. They can then be easily and safely handled with a camel's-hair brush.

Our experience has shown us that for very critical test spraying it is advisable to spray a control series with a standard insecticide on the same day. This is due to the extraordinary seasonal variations that may occur in the general resistance of insects (aphides in particular). So far we have not been able to ascertain precisely the causes

of these variations, but meteorological conditions would seem to play some part. It seems probable that insects are somewhat less resistant on cool and overcast days, than on days that are bright and warm.

On one or two occasions tests have been carried out on Lepidopterous larvae, using this apparatus, various methods for preventing their escape being tried. This can be successfully accomplished by placing the larvae in the glass dish and covering it with a piece of washed tulle stretched in a small wooden embroidery frame. The mesh of the tulle used was sufficiently small to prevent the larvae from escaping quickly, and the threads were so fine that the amount of the spray fluid held up was very small.

Test Sprays with Nicotine.

These were carried out at a number of concentrations ranging upwards from 0.0025 per cent. Owing to temporary difficulties in rearing large numbers of suitable aphides only 50 insects were sprayed for each concentration. As the accuracy of results obtained in experiments of this type is proportional to the square root of number of test subjects, it is probable that 50 per test is not a sufficient number for great statistical exactitude.

The results are, however, set out in Table IV and text-fig. 2 to show the type of curve that one is likely to obtain from a series of spraying experiments.

TABLE IV.

Showing Toxicity of various Concentrations of pure Nicotine to *A. rumicis* (adult apterous agamic females).

1st Series.			50 sprayed, 10 at a time.		
Concentration %	Number of Insects used (actual).	Number unaffected.	Number affected.*	% Affected of total number treated.	% Affected in test calculated to control.
0.0025	48	47	1	2	2
.005	49	46	3	6.5	6.5
.01	50	47	3	6.0	6.0
.02	47	35	12	25.5	25.5
.04	50	20	30	60	60
.06	50	4	46	92	92
.08	49	1	48	98	98
Control	47	47	0	0	—
2nd Series.					
0.0025	50	45	5	10	3.7
.005	46	42	4	8.7	2.3
.01	50	47	3	6.0	0
.02	46	35	11	24	18.7
.03	46	26	20	43.5	39.6
.04	49	18	31	63.3	60.8
.06	50	10	40	80	78.6
.08	50	7	43	86	85.0
.1	50	2	48	96	95.7
.15	50	2	48	96	95.7
.2	50	0	50	100	100
Control	45	42	3	6.5	—

Where the number tested differs from 50, one or two insects have escaped after spraying.

In all the above tests, including controls, 1 per cent. of saponin was used as a wetting reagent.

* The term "affected" indicates resultant death.

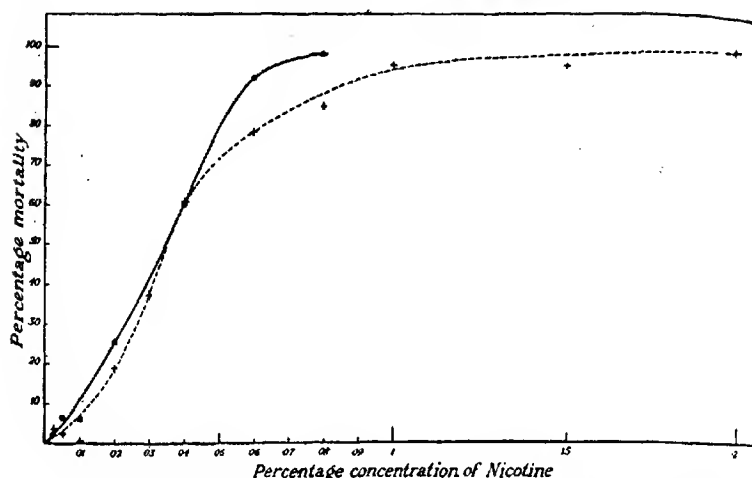


Fig. 2. Typical curves showing relation between concentration and toxicity for nicotine.

The figures in the last column are obtained by deducting the percentage affected in control (a) from the percentage affected in the test (b) and multiplying by $\frac{100}{100-a}$, the percentage affected calculated to control is then $(b-a) \cdot \frac{100}{100-a}$.

The curves are drawn freehand to cut as many points as possible, and we have expressed both of them in the sigmoid form, but the lower points vary too much to make this type, although very probable, an absolute certainty.

An inspection of Table IV and fig. 2. shows that the results obtained agree most closely in the neighbourhood of the 50 per cent death-point, substantiating the conclusion arrived at on statistical grounds that this is the best point for direct comparison of results.

One very important feature of these curves is the way in which they tail off gradually as the 100 per cent. death-point is approached, rendering any comparison of toxicities near this point, a matter of considerable uncertainty.

We are greatly indebted to Mr. R. A. Fisher, Chief Statistician to the Rothamsted Experimental Station, for the following note setting out the best means of comparing the toxic values of insecticides.

"In any given experimental conditions the probability of any particular insect dying must be regarded as a continuous function of the concentration of the insecticide used. The control gives any experimental value of the probability of death corresponding to zero concentration, and with any effective insecticide we must imagine that as the concentration is increased, the probability of death increases from this minimum value, until possibly a final concentration is reached at which death is certain.

"The relation between concentration and probability of death could theoretically be determined by experiment by exposing a large number of insects to the action of the insecticide at each concentration. The number of insects required, however, increases enormously if we wish to explore in this manner the region in which the probability of death is high. If as many as 99 per cent. of the insects were killed, the accuracy of the comparison between any two insecticides would depend upon the comparatively few insects which survived, and to compare them with any accuracy

many thousands of insects would have to be used. The same difficulty arises in the comparatively unimportant case when the deaths are few. For a given number of insects the most accurate comparison can be made when the concentrations are such that about 50 per cent. perish. The region between 25 per cent. and 75 per cent. can be fairly easily explored. It is for this reason that the preliminary examination of chemical substances should be made by a comparison of the concentrations required to give a mortality of 50 per cent. ; when the equivalence at this point is established, it would further be most valuable to ascertain if the same relative concentrations are equivalent over the range 25-75 per cent. Only in this way does it seem possible to infer a general equivalence of insecticidal properties. The direct comparison of mortality when the probability of survival is very small would seem to be beyond the scope of accurate laboratory investigation."

Summary.

An apparatus for determining the relative toxicities of contact insecticides is described in detail. It is so arranged that successive batches of insects are sprayed under conditions as similar as possible, so that on using various substances at different concentrations, the results are directly comparable.

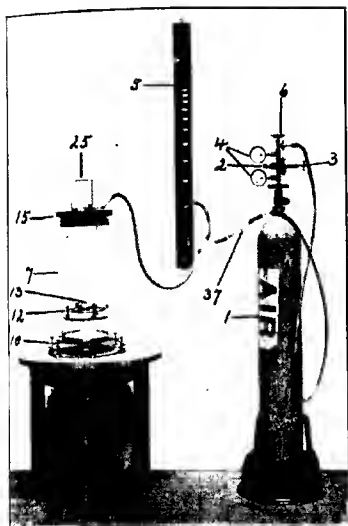
The apparatus consists of a glass jar in the lid of which an atomiser is fixed. By means of compressed air at known pressure the atomiser throws a constant quantity of fine spray upon insects placed in a dish inside the jar. Photographs illustrating the details of the apparatus are given.

The method used in practice for the spraying of aphides in this apparatus is described, and examples are given in the form of a table and a graph of the type of results obtained when different concentrations of nicotine are sprayed upon apterous agamic females of *A. rumicis*.

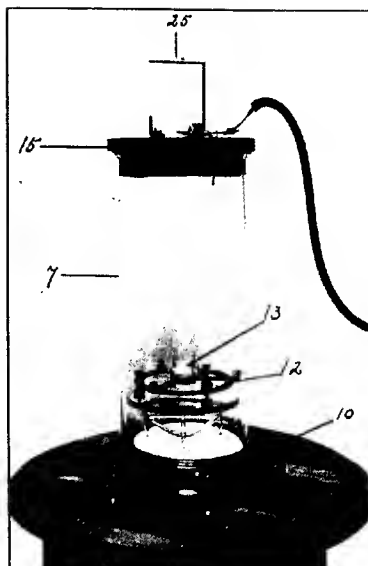
Two notes from the Statistical Department at Rothamsted are included, one analysing the accuracy with which the instrument sprays and the other giving reasons for regarding the concentrations which kill 50 per cent. of the insects sprayed as the most suitable for the direct comparison of the toxicity of insecticides.

EXPLANATION OF PLATES XXI. AND XXII.

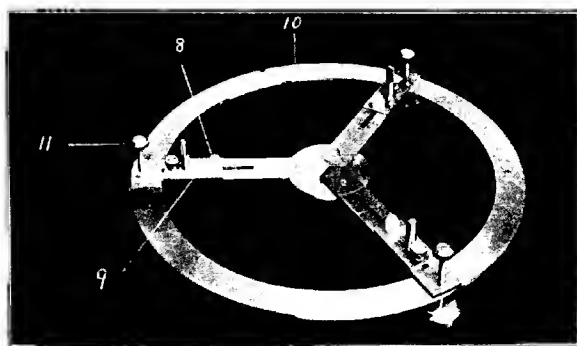
- A. Complete apparatus. \times about $\frac{1}{25}$
 - B. Glass jar with top and levelling platforms in position. \times about $\frac{1}{9}$.
 - C. Large external levelling platform. \times about $\frac{1}{5}$.
 - D. Small internal levelling platform. \times about $\frac{1}{5}$.
 - E. Top of jar. \times about $\frac{1}{10}$.
 - F. Details of top of jar. \times about $\frac{1}{5}$.
-
- 1. Cylinder of compressed air.
 - 2. Pressure-regulating valve.
 - 3. Thumb-screw for adjusting same.
 - 4. Dial gauges.
 - 5. Manometer.
 - 6. Air tap.
 - 7. Glass jar.
 - 8. Ivory points for levelling platform.
 - 9. Sliding plate carrying same.
 - 10. Large levelling platform.
 - 11. Levelling screws.
 - 12. Small levelling platform.
 - 13. Glass dish.
 - 14. Ivory-pointed centring screws.
 - 15. Mahogany top.
 - 16. Centring blocks of top.
 - 17. Screws locking blocks.
 - 18. Nozzle.
 - 19. Air tube of nozzle.
 - 20. Liquid tube of nozzle.
 - 21. Wider tube to fit in clamp.
 - 22. Clamp.
 - 23. Block holding clamp.
 - 24. Small plate.
 - 25. Gallows and plummet.
 - 26. Plummet.
 - 27. Holes in plate fitting over points.
 - 28. Points.
 - 29. Intermediate plate.
 - 30. Clamp for small plate.
 - 31. Ball.
 - 32. Socket.
 - 33. Adjusting screws between intermediate and basal plates.
 - 34. Glass tube.
 - 35. Clip for glass tube.
 - 36. Basal plate.
 - 37. Air filter.
 - 38a, b. Upper and lower milled nuts, giving means of fine adjustment
between intermediate and basal plates.



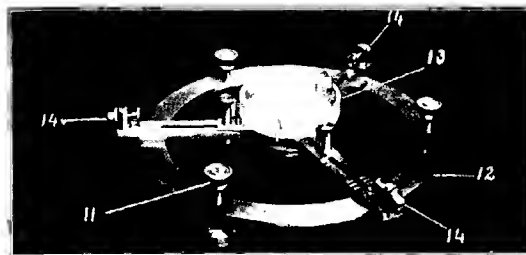
A. General view of apparatus as arranged for use.



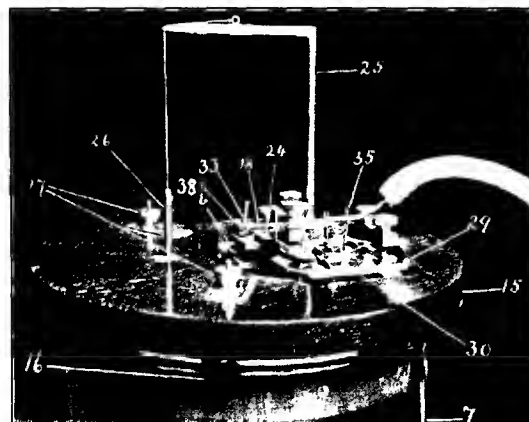
B. Glass jar with levelling platforms and lid.



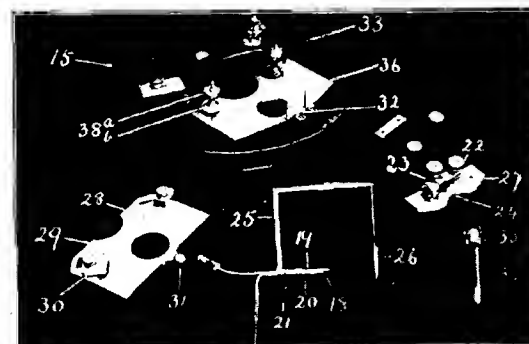
C. External levelling platform.



D. Internal levelling platform.



E. Lid of jar with nozzle.



F. Details of lid of jar and arrangements for adjusting nozzle.

A PRELIMINARY REVISION OF THE ORIENTAL SPECIES OF LEPTOCORISA, LATR. (HEMIPTERA, COREIDAE).

By W. E. CHINA.

Members of the genus *Leptocorisa* have long been known in the East as serious pests of rice. A great deal of confusion, however, has existed between the various species, and in many cases there has been considerable uncertainty as to the identity of the insect responsible for damage in any given locality. *L. varicornis*, F., and *L. acuta*, Thunb., in particular, have been constantly confused. Leopoldo Uichanco, for example, expressed some doubt as to the determination of the species described by him in his paper on the Philippine rice bug (Philippine Agric. Review, xiv, 1921, pp. 87-125). This confusion was due, no doubt, not only to the general similarity of the two species and the briefness of the original descriptions, but also to the existence of other closely allied species.

Thanks to the Imperial Bureau of Entomology and to the courtesy of Mr. G. H. Corbett, Government Entomologist, Federated Malay States, I have been able to study a very large amount of *Leptocorisa* material. The species of this genus are extremely alike in general appearance and structure and cannot be separated by the characters usually employed. The venation of the hemelytra and wings and the punctuation of the sclerites is very constant throughout the genus. The head appears to vary slightly in the shape of the apices of the tylus and juga, and the relative length of the antennal joints is of value; but the species are most readily separated by the structure of the male genital claspers. This character, however, is rather difficult to make out in the field and cannot of course be applied to the female. I have therefore endeavoured to make a key to the species, using such obvious characters as are available and based in each case on a large number of specimens separated by the male genital claspers. This key is necessarily superficial and by no means comprehensive of all the forms and varieties of this difficult genus. However, it will I hope be of some service when used with the accompanying descriptions, but in cases of ambiguity reference must be made to the male claspers. The chief difficulty in the study of these organs is that owing to their complicated twist they must always be compared from the same angle of vision. The best views are obtained by partly opening the claspers and viewing them end on, that is along the axis of the body, and also vertically downwards from the dorsal side.

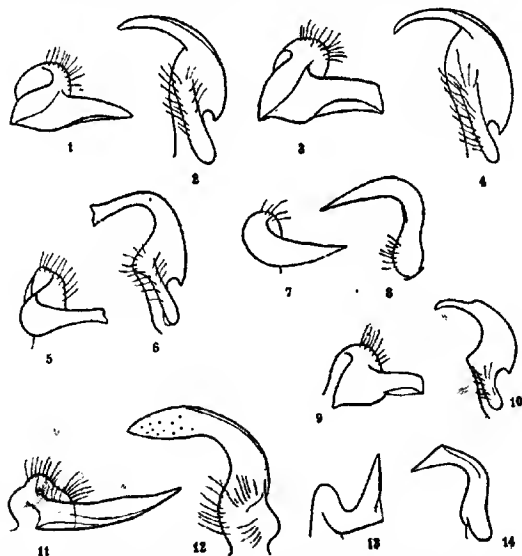
Key to Oriental Species of *Leptocorisa*.

1. (2). Posterior third of abdomen above black; apical joint of antennae pale at base and apex; male claspers narrow at base, but ending at apex in a flat expansion strongly and obliquely truncate *costalis*, H. Sch.
2. (1). Abdomen above entirely reddish or ochraceous.
3. (4). Rostrum extending to posterior coxae; disc of pronotum posteriorly and pleurae dark brown; apical joint of antennae pale only at base; male claspers wide at base, suddenly narrowed towards the apex, which is truncate *discoidalis*, Walk.
4. (3). Rostrum not extending to the posterior coxae; disc of pronotum, scutellum and pleurae not dark brown.
5. (6). Species small and slender, not longer than 13 mm.; male claspers narrow at base, slender, rounded, strongly curved and sharply pointed *lepidula*, Bredd.
6. (5). Species larger and more robust, more than 13 mm. in length.
7. (8). Basal joint of antennae and legs pale unicolorous; sometimes with lateral spots along the abdomen below; male claspers wide at base, with the extremity curved and tapering to a point *acuta*, Thunb.

8. (7). Basal joint of antennae not pale and unicolorous.
 9. (10). Basal joint of antennae entirely dark brown; male claspers very broad at base, with extremity truncated and not pointed ... *corbetti*, sp.n.
 10. (9). Basal joint of antennae pale with the apex dark brown or black.
 11. (12). Legs pale unicolorous; male claspers slightly bifid at apex ... *varicornis*, F.
 12. (11). Legs with extreme apex of femora and extreme base of tibiae black; male claspers wide at base, extremity curved, flattened, bluntly pointed *geniculata*, sp.n.

***Leptocoris acuta*, Thunb.**

This is the largest and most robust of the Oriental species. The general colour is pale ochraceous, with the abdomen above reddish ochraceous; usually there are six brown spots on the abdomen below, placed one on each side of the third, fourth and fifth apparent abdominal ventrites, but often these spots are entirely absent; in one or two specimens a fourth pair of spots is present on the second apparent abdominal ventrite. The legs are entirely pale ochraceous. Antenna with the basal joint always unicolorous ochraceous, the remaining joints being dark with their bases pale, but the colouring is rarely so distinct as in *varicornis*, F.; the apical joint is more than one and a half times, but less than twice, as long as the second. The small triangular membrane at the apex of the clavus is almost entirely hyaline, only the posterior margin being brown. The male genital claspers (figs. 1, 2) are wide at the base with the extremities tapering to an obtuse point; they resemble those of *L. corbetti*, sp. n., when viewed along the axis of the body, but differ in not being flattened and truncate at the apex when viewed vertically downwards.



Male genital claspers of Oriental species of *Leptocoris*: 1, 2, *L. acuta*, Thunb.; 3, 4, *L. corbetti*, sp. n.; 5, 6, *L. varicornis*, F.; 7, 8, *L. lepida*, Bredd.; 9, 10, *L. discoidalis*, Walk.; 11, 12, *L. geniculata*, sp. n.; 13, 14, *L. costalis*, H.S. x 56.

In each case the first figure is as seen when viewed vertically downwards from the dorsal side, and the second as seen viewed along the axis of the body.

Average total length, ♂ 16 mm., ♀ 17 mm.; width across posterior margin of pronotum 2.8 mm.; length of antennal joints in ♂ 5, 3.5, 4, and 6.4 mm.

Widely distributed over the Oriental Region, but does not extend so far as *varicornis*, F. Redescription based on 93 specimens from Ceylon, South India, Himalayas, Assam, Tonkin, Siam, Malay Peninsula, Sumatra, Java, Bali, Sarawak, Celebes, Philippines and Ceram.

***Leptocorisa varicornis*, F.**

This is a much narrower and more slender insect than *acuta*, Thunb. The general colour, however, is similar but rather deeper. The legs are pale ochraceous, with the femora towards their apices somewhat darker. The basal joint of the antennae is nearly always ochraceous with the apex black, but in a few specimens the whole basal joint is brown, while in all the specimens from Fiji and New Hebrides the basal joint is entirely pale; the remaining joints are dark with their bases pale, the apical one being more than twice the length of the second. The small triangular membrane at the apex of the clavus is hyaline anteriorly, but shades to dark brown posteriorly. The male genital claspers (figs. 5, 6) are distinct in being slightly bifid at their extremities.

Average total length, ♂ 15 mm., ♀ 15.5 mm.; width across posterior margin of pronotum, 2.3 mm.; length of antennal joints, 4.4, 2.7, 3.1, and 5.7 mm.

This is the most widely distributed of all the Oriental species. Redescription based on 60 specimens from Ceylon, North India, Assam, Burma, Tonkin, Malay Peninsula, Sumatra, Java, Timor, Sarawak, Philippines, Formosa, China, Ceram, Mysol, New Hebrides, Fiji, Tonga Is., Queensland and N.W. Australia.

***Leptocorisa corbetti*, sp.n.**

♂. General colour above ochraceous, strongly tinged with olivaceous. Eyes black, ocelli red; head below pale, with the antenniferous tubercles below and a small lateral stripe behind each eye, dark brown; length 2.2 mm., width between the eyes 0.9 mm. Antennae: basal joint black, inner sides at base dark brown, length 5 mm.; second joint black, with the basal sixth yellow, length 3 mm.; third joint black, with basal tenth yellow, length 3.7 mm.; apical joint black, with basal seventh yellow, length 7 mm. Rostrum ochraceous, with sutures and apex of fourth joint black, extending to intermediate coxae; length of joints, 1.5, 1.5, 0.8, and 0.7 mm. Pronotum olivaceous, strongly punctate, with a short median impunctate carinate line and a pale obsolete rounded carina along the posterior lateral margins; posterior angles dark brown, impunctate, raised in form of round obsolete tubercles, anterior collar with a short lateral brown stripe behind the eye; length of pronotum 2.8 mm., width across posterior margin 2.6 mm. Meso- and metasternum pale ochraceous; scutellum, length 1.6 mm. Hemelytra pale ochraceous along the costal margins, with the clavus and inner half of corium olivaceous brown; veins pale, small triangular membrane at apex of clavus entirely brown, but much darker posteriorly; membrane pale fuscous hyaline with the extreme base dark brown, extending to apex of abdomen. Abdomen above pale reddish ochraceous with the connexivum paler; below pale ochraceous, immaculate. Femora ochraceous, with the extreme apices black; tibiae brown, with the extreme bases and apices black, the apical half darker than the basal half; tarsi black, with the exception of the basal half of the first joint which is ochraceous; length of femora, anterior to posterior, 4, 4, 6.5 mm.; tibiae, 4.3, 4.3, 7 mm. Genital claspers (figs. 3, 4) very broad at the base, with the apex truncated and not pointed; the lower edge of the distal portion before the apex is very thin and semitransparent.

Total length 16 mm.

♀. Similar to ♂, with shorter antennae; lengths of joints, 4.3, 2.7, 3.1, and 5 mm.

6 ♂♂ and 5 ♀♀ (type and paratypes) Setapak, Federated Malay States (*G. H. Corbett*); 19 other paratypes from Sumatra, Singapore, Laos, Upper Mekong and China.

This species seems to be intermediate between *acula*, Thunb., and *varicornis*, F. It is somewhat variable in size, some specimens only measuring 14 mm. Specimens from China are much paler in colour, the basal joint of the antennae being ochraceous with only the apex black. The genital claspers, however, are identical with those of the dark specimens from Malaya.

***Leptocoris geniculata*, sp.n.**

♂. General colour above dull reddish ochraceous. Eyes dark brown, ocelli dull yellow; head pale below, with the antenniferous tubercles below and a small lateral stripe behind each eye dark brown; length 2 mm., width between eyes 0.8 mm. Antennae: basal joint fulvous with the apical eighth black, length 5.3 mm.; second joint with the apical half dark brown and the basal half pale ochraceous, length 3.7 mm.; third joint dark brown with the basal sixth pale ochraceous, length 4 mm.; apical joint pale brown with the basal third yellow, length 5.8. Rostrum pale ochraceous, with the sutures brown and the apex of the fourth joint black, extending to intermediate coxae; length of joints 1.3, 1.3, 0.8, and 0.7 mm. Pronotum dark ochraceous, strongly punctate, with a short medium impunctate carinate line and an obsolete rounded carina along the posterior lateral margins; posterior angles with the brown impunctate raised spots less prominent than in *L. corbeti*; anterior collar with a short lateral brown stripe and the propleurae anteriorly brown; length of pronotum 2.8 mm., width across posterior margin 2.6 mm. Meso- and metasternum dirty ochraceous, the odoriferous area dark olivaceous grey. Scutellum ochraceous, length 1.6 mm. Hemelytra ochraceous, with the clavus and inner half of the corium pale brown; veins pale; small triangular membrane at apex of clavus brown as in *L. corbeti*; membrane pale fuscous hyaline, extending to apex of abdomen. Abdomen above dirty reddish ochraceous, with the connexivum pale greyish; below dark olivaceous grey, immaculate. Femora rich fulvous, with the extreme apices black; tibiae ochraceous, with extreme base and apex dark brown; tarsi dark brown, except the basal joint which is ochraceous with the apical half brown; length of femora, anterior to posterior, 4.7, 4.8, and 7.7 mm.; length of tibiae, 4.8, 5, and 8 mm. Male genital claspers (figs. 11, 12) very distinct, wide at base, with the distal portion long ovate, flattened and bluntly pointed.

Total length, 16.4 mm.

♀. Similar to ♂, with the antennae shorter; length of joints, 5, 3, 3.3, and 5.3 mm.

18 ♂♂ and 30 ♀♀, Philippine Is. (*J. J. Mounsey*); 1 ♂ and 1 ♀, Mindoro, Philippine Is. (*J. J. Mounsey*).

This species is only recorded from the Philippine Is. It is apt to be confused with specimens of *L. corbeti* from China, but the dark greyish underside and the strikingly distinct male genital claspers will distinguish it.

***Leptocoris lepida*, Bredd.**

This is the smallest and the most slender species of the genus. It is somewhat variable in size, but does not exceed 12 mm.; width across posterior margin of pronotum 1.8 mm. It is very variable in its colouring, particularly of the antennae; the basal joint is sometimes entirely pale ochraceous, but usually has the apex black; in some specimens however the basal joint is entirely black; the second and third joints are dark brown with the bases pale, the fourth being brown with the base pale. The hemelytra are ochraceous, with the clavus and inner half of the corium brown; the triangular membrane at the apex of the clavus is entirely brown. The legs are usually fulvous with the apices of the tibiae brown, but in dark specimens the

tibiae may be entirely brown. The abdomen above is bright reddish ochraceous, but below very pale ochraceous or greenish. The male claspers (figs. 7, 8) are very distinct, slender, rounded and smooth, with the bases narrow and the distal portion curved and tapering to a sharp point.

Length of antennal joints in ♂, 3.3, 2.2, 2.5 and 4.3 mm. Redescription based on 28 specimens from Ceylon, Dehra Dun, Sikkim, Burma, Federated Malay States, Singapore, and Sarawak.

***Leptocorisa costalis*, H.S.**

This very distinct species is somewhat variable in size but is otherwise very constant. The head and pronotum are usually bright ochraceous but in some specimens the disc of the pronotum posteriorly is distinctly greenish; the short lateral black line below the eye and the black spots in the posterior angles of the pronotum are very distinct. The antennae are black, with the base and apex of the apical joint yellow. The hemelytra are dark brown or black with the costal margins pale ochraceous. The rostrum extends a little beyond the intermediate coxae. The scutellum is ochraceous. The abdomen above is reddish ochraceous with the apical third or half black; below it is pale greenish yellow or ochraceous. The femora are ochraceous with the apical half dark brown or black; the tibiae and tarsi are dark brown or black. Male claspers (figs. 13, 14) narrow at the base, with the distal portion expanded, flattened and strongly obliquely truncate.

Average total length, 15 mm.; width across the posterior margin of the pronotum, 2.6 mm.; length of antennal joints, 4.3, 2.7, 3, and 5.7 mm.

Redescription based on 22 specimens from Burma, Siam, Tonkin, Malay Peninsula, Java, Borneo, Gilolo, Mysol, and Formosa.

***Leptocorisa discoidalis*, Walk.**

This species closely resembles *L. costalis*, H. S., in general colouring. The abdomen above however is entirely reddish ochraceous, the rostrum extends to the posterior coxae, and there is a dark brown stripe widening posteriorly and extending over the pleura from behind the eye to the posterior coxae. In the majority of specimens the disc of the pronotum posteriorly is dark brown or even black, but in a few it is dark ochraceous or unicolorous with the head. The scutellum is ochraceous with the base sometimes dark brown. The basal joint of the antennae is fulvous with the apex black, the second and third joints black with their extreme bases ochraceous, and the apical joint is brown with the basal third yellow. Legs dark brown with the basal half of the femora ochraceous. Male claspers (figs. 9, 10) similar to those of *L. corbetti*, but suddenly narrowing towards the apex, with the thin transparent lower edge convexly sinuate.

Average total length, 15 mm.; width across posterior margin of pronotum, 2.6 mm.; length of antennal joints, 5, 3.1, 3.5, and 6 mm.

Redescription based on 11 specimens from New Guinea, Ceram, Aru, and New Hebrides (including the type from New Guinea).



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Permanent marshes formed by the blocking of rivers by coastal dunes: Wadi Ghuzze (above) and Wadi Sukereir (below), showing masses of Potamogeton. (Photographs by J. Mieldazis, Int. Health Board, Rockefeller Foundation.)

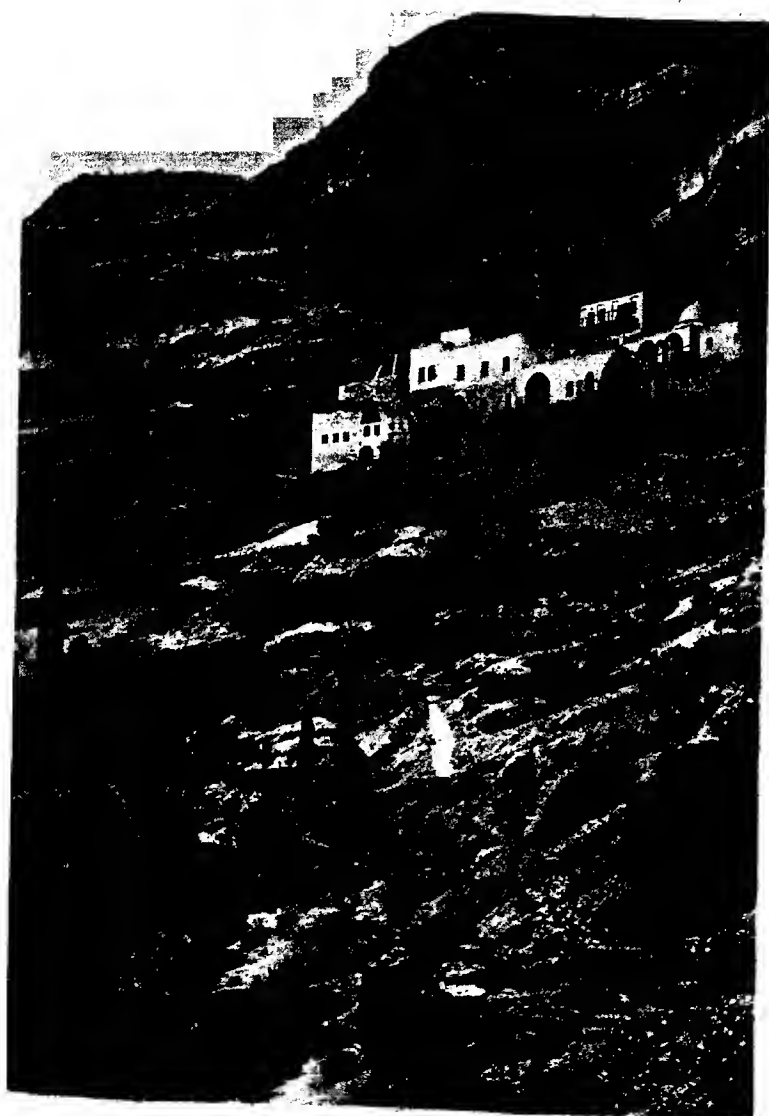


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River Jordan near Jentcho, showing sharply cut sides and, on the right, a jungle of Tamarix, Populus, etc., which is liable to be flooded. (Photo by American Colony.)

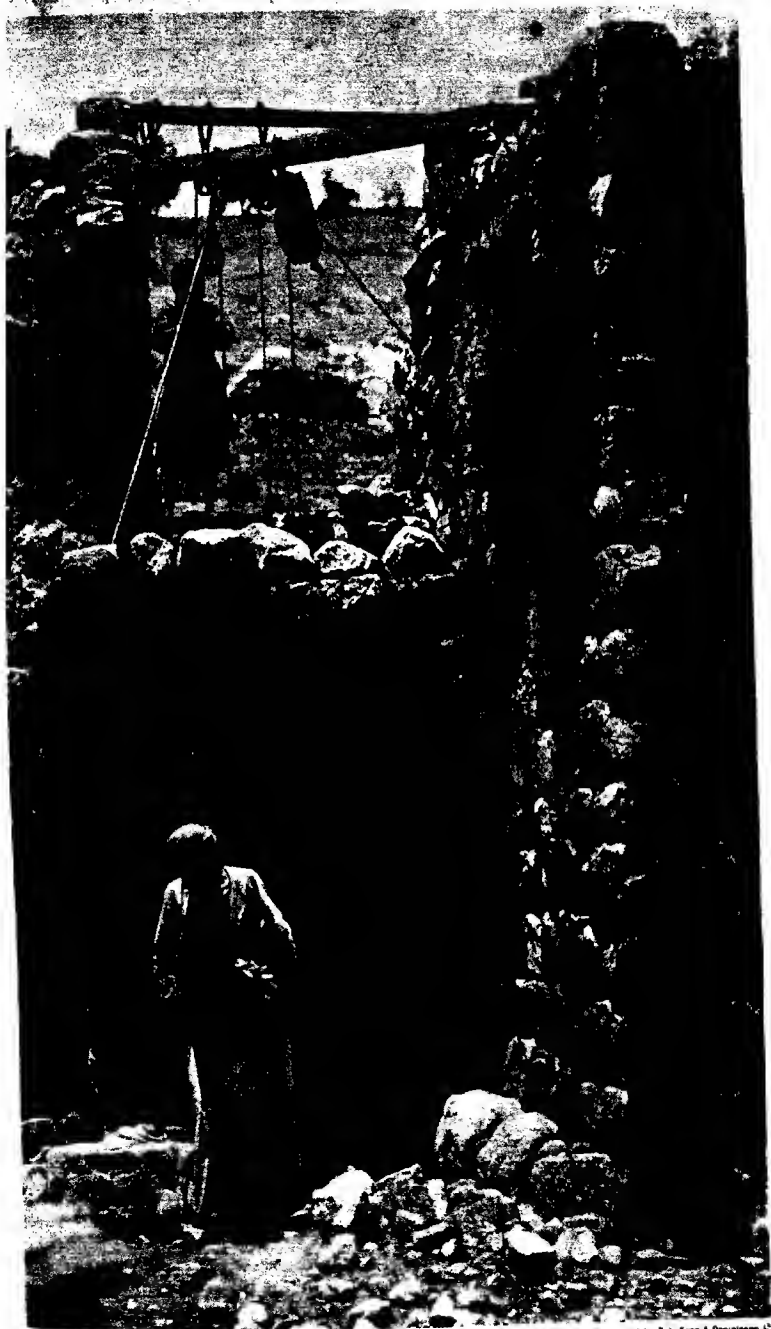


Pebbly shore of Lake of Tiberias, near Mejdel. Anopheles argenti breeds at the water's edge among or under



John R. Sorensen & Danneberg (1944)

Convent of St. George, Wadi Kelt. Anopheles superpictus breeds under boulders in the stream-bed. (Photo. by American Colony, Jerusalem.)



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Job's Well, Jerusalem, a breeding place of Anopheles bifurcatus. (Photo. by American

SOME OBSERVATIONS ON THE VARIABILITY OF LOCUSTA MIGRATORIA, L., IN BREEDING EXPERIMENTS.†

By V. I. PLOTNIKOV.

Director of the Turkestan Entomological Station.

My breeding experiments on *Locusta migratoria*, L., in 1913-14 enabled me to establish that the progeny of this species sometimes belongs to the form which was previously regarded as a distinct species, *L. danica*, L., and in the same way, the latter insect may give rise to progeny that is typical of *L. migratoria*. These results have been used by B. P. Uvarov in developing his theory that the periodicity of locusts is due to a kind of irregular alternation of two phases, swarming (ph. *migratoria*) and solitary (ph. *danica*), respectively. I shall not dwell here on that theory or on the differences between the two phases, referring those interested in the subject to Uvarov's paper††, but will describe further breeding experiments conducted during the year 1923 with a view to obtaining an idea as to what may be the factors that cause the variation in the species.

The most obvious difference between the two phases being in the coloration of the larvae, this character and its variability have been studied in the experiments.

The larvae may be classified, according to their coloration, into three, not two, categories: (1) "migratoid," (2) green, and (3) "danicoid." Intermediate forms also occur between all three types of coloration, and the various types can usually be recognised definitely in the third larval stage.

Larvae of the coloration which I call "migratoid" have the upper side of the head black, the pronotum velvety black above, the wing-pads black, two black lateral stripes along the median line of the abdomen, and two more along the lower margin of its sides, while all other parts are reddish brown. The black pigment is concentrated in the chitin, as may be observed on the skins left after a moult; the hypodermal cells under the black chitin are coloured brown and black. Those parts of the body that are reddish brown have the hypodermal cells of the same colour, and the chitin slightly brownish.

The green larvae are green above, with pale stripes on the abdomen corresponding to the black ones in the migratoid larvae; the head, thorax and abdomen beneath are pale brownish. The green and brownish colours depend on the colour of the hypodermal cells, the chitin being in this case colourless, with only some black dots corresponding to small groups of black cells in the hypoderm.

Danicoid larvae are more or less unicolorous, but vary from charcoal-black to pale brownish or greyish. Their coloration is due to the hypodermal cells, and its intensity depends on the density of the black dots in the chitin; a confluence of the dots results in the black coloration.

A transition from the migratoid coloration to the green one during the moults is produced by the brown pigment turning green and by the reduction of the velvety black stripes on the pronotum, which may disappear completely. Danicoid coloration is often transformed during the moults under altered conditions into the green.

For the experiments a special type of open-air cages has been largely used. Squares of turf with growing grass, 4 square metres in size, were included in walls of sheet iron, 60 cm. high, with the upper margin rectangularly bent inwards; in some cases the lower part of the walls was made of wire netting. The cages were covered with wire netting to prevent the larvae from being destroyed by birds and wasps. Ordinary cages and glass jars were also used in experiments.

† Translated from the Russian manuscript by B. P. Uvarov.

†† Bull. Entom. Res., xii, 1921, pp. 135-163.

On the 26th May I took from an ordinary cage of 0.02 cub.-metre in volume, 80 larvae of the third stage of typical migratoid coloration, and transferred them to an open-air ground cage as described above; an equal number of larvae were left in the original cage. After a while it was observed that the larvae in the ground cage began to turn green, and on 11th June, when they attained the fifth stage, they had become quite green; but six of them became dark grey, almost black. In the original cage all the larvae kept their migratoid coloration.

The same experiment was repeated with larvae of danicoid coloration and with the same result, but only green larvae were obtained in the ground cage.

As many as 15 experiments with larvae of the second brood of *danica* reared under conditions of overcrowding yielded interesting results. When the larvae were kept from the first stage in small cages or glass jars at a density of 30-50 larvae to 450-675 cub. cm. of space, a typical migratoid coloration was invariably obtained. In experiments in which the density of population was less, 20 larvae to 2,000 cub. cm. of space, besides the migratoid larvae, some green and danicoid, but not dark, specimens were obtained.

When the larvae were kept singly in glass jars they began turning green as early as in the second stage, and in the 4th-5th stages they invariably became quite green. When larvae of the first stage were placed in groups of four in small glasses, about 100 cub. cm., the resulting larvae of the fifth stage presented a mixture of migratoid and green larvae, as well as some transitional forms.

These experiments show that the migratoid coloration is retained only when the larvae are crowded together. It must be added also that the migratoid larvae obtained in that way do not show the highly crested pronotum, *i.e.*, they are migratoid not only in coloration but also in structure.

Another series of experiments was conducted to ascertain the effect of overcrowding on larvae that were not migratoid originally. On 6th August 86 larvae of the 2nd-3rd stages and of various colorations except migratoid were placed in a cage 2,000 cub. cm. large. On the 14th of the same month, when the larvae had attained the 4th-5th stages, as many as 45 larvae were of the regular migratoid coloration; while in nine more the brown colour of the sides was replaced by green, otherwise they were also migratoid in type. An experiment in which 44 green larvae were crowded together in a cage of 1,000 cub. cm. resulted in a few typically migratoid larvae and some approaching the migratoid coloration, while in others a general darkening was observed; in some specimens a pinkish colour appeared on the sides and underside of the abdomen.

What are, then, the factors which produce the migratoid coloration of larvae when bred in crowded cages?

One of the suggestions may be that the cannibalism of the larvae, which is often observed under such conditions, is of importance in this respect. However, experiments in which larvae of migratoid coloration were kept singly in glasses and fed on killed larvae disproved this suggestion, as the larvae turned pale or green.

Neither can moisture be regarded as a factor producing the migratoid coloration, as experiments in glass jars with very high humidity have given different results, while the breeding of a large number of larvae in the open-air ground cages, in which the humidity was very much lower than in jars, produced nothing but migratoid coloration. It may be mentioned, by the way, that it is impossible to breed locust larvae in a very dry atmosphere, as many of them die; it is necessary to spray the food with water, which of course increases the moisture of the air in the cages.

Temperature is also scarcely of any importance, since exactly the same results were obtained in the hot midsummer as in the autumn (October).

Is it not the light which influences the coloration? The following experiments give, apparently, a negative answer:—Breeding isolated larvae in glass jars, either in

darkness or in light, results in the green coloration; while breeding crowded larvae (40 larvae to 450 cub. cm.) in darkness produces migratoid coloration.

Thus, the actual factors producing migratoid coloration remain obscure, but the following observations tend to show that the problem of coloration is a very important one.

In three of the experiments in which larvae of *migratoria* were bred in open-air ground cages I obtained, apart from the green larvae, some of a very dark, almost black coloration; 4-8 per cent. of the larvae were of that type. In one of these experiments a large number of pieces of charcoal were put on the ground, but they did not affect the percentage of the black larvae, as only 16 out of 200 kept in the cage turned black. In all cases the black larvae were of the female sex. When isolated in the fourth stage in glass jars, some of them produced green larvae in the fifth stage.

The behaviour of these larvae was quite peculiar. When they were kept with the green larvae, they were fairly lively, but when the green ones were removed, it became very difficult to find the black larvae amongst the grass; in the cage with charcoal some of them had concealed themselves under the lumps.

Larvae of the same type of coloration are found sometimes in nature, and I always observed them sitting singly on stems of *Phragmites*. What is the explanation of this? Did their coloration affect their behaviour, or did their behaviour react on their coloration?

I have described above an experiment in which equal numbers (80) of larvae of *migratoria* were kept in a spacious open-air cage and densely crowded in an ordinary cage. Six of these black individuals were found afterwards in the open-air cage, and it seemed reasonable to expect that about the same number would appear in the small cage, yet there were none; as if a close association with the others prevented them from developing their individual peculiarity.†

†The experiments described in this paper are extremely interesting, as they show that the problem of transformation of the swarming phase of locusts into the solitary one is very complicated, and the actual factors of transformation not easy to discover. The results of the experiments are in most remarkable agreement with those obtained by Professor Faure with the South African *Locustana pardalina* (Journ. Dept. Agric. S. Africa vii, 1923, no. 3, pp. 205-224), in which crowding of larvae of the solitary phase also invariably led to transformation into the swarming phase, while larvae of the swarming phase bred singly transformed into solitary ones. It is difficult even to suggest what the factors of transformation are, but one point seems to be fairly clear—that the transformation is due to some unknown influences on the larvae, not on the eggs or the adults, and that those influences are in some way connected with the density of larvae in a given space. Only further extensive and more precise experiments, in which all possible factors would be carefully registered and measured, can throw better light on this highly interesting and mysterious phenomenon.—B. P. Uvarov.]

A NEW HISPID BEETLE INJURIOUS TO OIL PALMS IN BRAZIL.

By S. MAULIK.

Through the courtesy of Dr. G. A. K. Marshall, F.R.S., I have had the opportunity of examining the new beetle, a description of which is given below. It was sent by Dr. G. Bondar to Dr. Marshall as occurring in Brazil on *Elaeis guineensis*. This plant, the African oil palm, is a native of tropical Western Africa, where it has a wide geographical distribution from the Gulf of Guinea to the South of Fernando Po. It flourishes in the Island of Zanzibar and along the shores of the Central African lakes, and has been introduced into the Philippine Islands, the West Indies and South America.

A Hispid beetle, when it is a pest, is a dangerous one. The larvae are leaf-miners and generally attack the unopened buds. They pass their whole larval life inside the leaves, where they pupate. The mature beetle also eats the leaves. As the larvae live in such a protected position it is a matter of great difficulty to cope with the insect when it becomes a pest. I have already recorded another Hispid beetle (*Coelacnomenodera elaeidis*, Maulik, Bull. Ent. Res., x., p. 171, January 1920) which attacks the oil palm in the Gold Coast.

The present insect belongs to the genus *Cephalolia*, subfamily HISPINAE, family CHRYSOMELIDAE. This genus is apparently confined to tropical or subtropical America, from Mexico to Brazil. No American genus of HISPINAE has yet been found in the Old World. The oil palm has been introduced into the New World, and the insect here described has evidently adapted itself to this new food-plant. It probably feeds normally on some indigenous species of palm, for Hispid beetles show a great partiality for these trees. The coconut is attacked by several species of this group of beetles, and some have been found to occur on the date palm in India.

***Cephalolia elaeidis*, sp. nov.**

Elongate, upperside of the body flat. Colour, shining black, with the edges of the prothorax and elytra, the legs and the abdominal segments pitch-brown.

Head: interocular space punctate, depressed and with a longitudinal, slightly elevated ridge along the middle line. The eyes strongly convex. The antennae about 2 mm. long, shorter than half the length of the body, of uniform thickness throughout; the two basal joints shining pitch-brown, the rest opaque, being covered with pubescence; the first joint long and the thickest, the second shorter, the third longer than the second, the fourth shorter than the third, the fifth to the last almost equal to each other in length, the last joint pointed. *Prothorax* quadrate with the sides straight, the basal line bisinuate, the anterior angles broadly rounded, the posterior acute. The edges of the sides are serrate. The upper surface gently convex from side to side, covered with coarser and finer punctures, the former being crowded on the lateral surfaces and the latter irregularly scattered on the disc, the middle longitudinal line being almost impunctate. *Scutellum* cuneiform, with the surface smooth and impunctate, and the apex acute. *Elytra* broader at the base than the prothorax, parallel-sided, punctate-striate, each elytron having ten rows of punctures, including an extreme marginal one; besides these there is a long scutellar one; towards the apex the punctures tend to become obliterated and meet in pairs. The interstices are flat, that between the ninth and tenth rows of punctures slightly elevated; posterior to the humeral callus the lateral surface is slightly concave, the interstices here being also slightly elevated. *Underside*: the abdominal segments and the legs covered with a brownish down. The legs are short, when in repose not visible from above; the tarsi short, the claw joint hardly projecting beyond the third bilobed joint. In the female the anal segment of the abdomen has a straight edge; in the male it is deeply emarginate (fig. 1, a, b).

Length, ♂ 4.5 mm., ♀ 5 mm.

BRAZIL: Bahia (Dr. G. Bondar).

Type in the British Museum; described from eleven specimens.

In the collection of the British Museum there are three specimens which are identical with this species, one of them bearing a label in Baly's handwriting with the name *Cephalotia soráida*, the locality being Bahia, Brazil. I can not find any published account of this insect under this name; *Cephalotia soráida* must therefore be regarded as a manuscript name. The present species is closely allied to *Cephalotia depressa*, Baly (fig. 1, c), but differs in having (1) the sides of the prothorax straighter and the anterior angles broadly rounded, (2) the surface structure of the area around the scutellum smoother.

Baly described *C. depressa* from one specimen which is in the British Museum Collection.

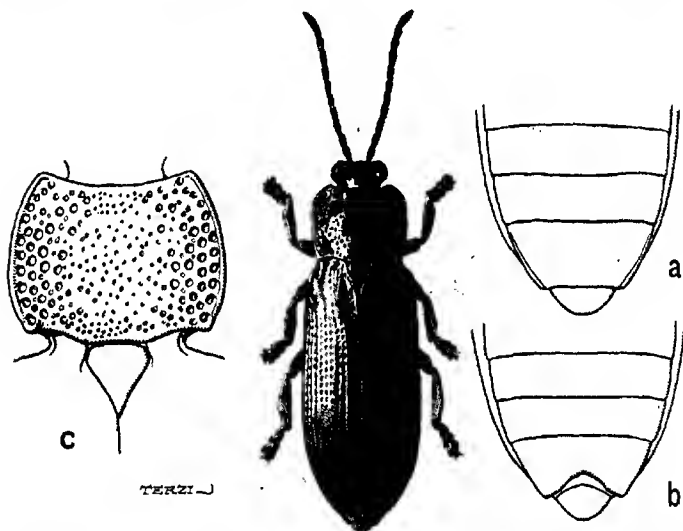


Fig. 1. *Cephalotia elaeidis*, Maulik, sp. n.: a, abdominal sternites of ♀; b, the same of ♂; c, pronotum of *C. depressa*, Baly.

A NEW PSYLLID INJURIOUS TO FIG TREES.

By F. LAING.

Trioxa buxtoni, sp.n.

General colour (in spirit) green with dark brown barring on abdomen. Antennae from the apical half of iv. to tip dark brown to black, basal segments pale brown. Head pale green, except for a black depression between the base of the lateral ocellar elevation and the median line; genal cones medium brown; lateral ocelli pink. Pronotum of the same uniform colour except for a small black area marginally. Dorsulum pale green, with two large semicircular or subtriangular light brown areas medianly anteriorly; mesonotum striated with light brown, one median narrow stripe and two broad lateral ones; mesoscutellum unicolorous or faintly tinged with brown. Legs with the femora darker than tibiae, tarsi and claws black. Abdomen with two median black areas on first segment, with a lateral hollow black area and a small median dark brown patch; the next five segments heavily and continuously barred with black. Abdominal sternites of a medium dark brown. Male genitalia pale brown, female genitalia rather dark brown.

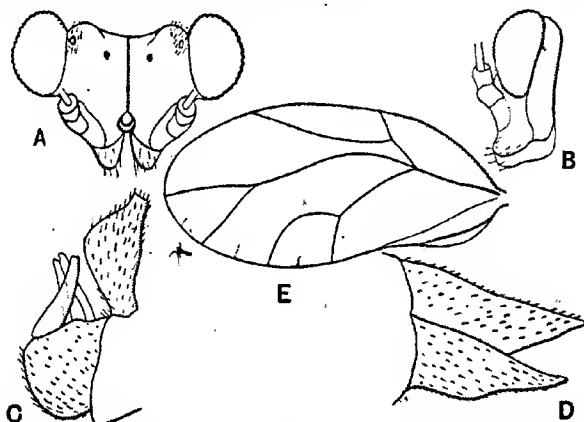


Fig. 1. *Trioxa buxtoni*, Laing, sp.n. A, head; B, side view of head; C, genitalia of ♂; D, genitalia of ♀; E, tegmen.

Head (fig. 1, A, B) not as broad as thorax, strongly arcuate on posterior margin, slightly declivous; vertex rather deeply depressed in the centre of each half, lateral ocelli slightly elevated. Genal cones very short, about half the length of the vertex, at first descending almost at right angles to vertex, then porrected almost horizontally, slightly hairy. Antennae about twice the breadth of the head in length. Dorsulum slightly more deep than broad, subtriangular; mesoscutellum subrectangular, with the anterior lateral angle slightly projecting. Hind tibiae without a spur at the base. Tegmen (fig. 1, E) hyaline, rounded at apex, about $2\frac{1}{2}$ times as long as broad. Genitalia: ♀ almost half the length of the abdomen, the dorsal valve very slightly longer than the ventral; ♂ with the dorsal margin of anal valve more or less straight, the ventral margin deeply convex in the middle (fig. 1, C); forceps wide at the base, tapering to the apex. Length of body, 3.6 mm.; length of tegmen, 3.2 mm.

PALESTINE: Lydda and Jericho, in galls on the leaves of *Ficus carica* (Dr. P. A. Buxton).

Near to *T. thomasi*, Lw., in the shape of the genal cones and the rounded apex of the tegmen, but differing in the coloration. "The gall is thickened, hairy, and projects on the upper side of the leaf. It is a very serious pest, many leaves being completely ruined by it" (Collector's note).

ON THE LIFE HISTORY OF *BORIOMYIA* (HEMEROBIUS) *NERVOSA*,
FAB. (PLANIPENNIA, HEMEROBIIDAE).

By HERBERT W. MILES, B.Sc.

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In October 1921, when banding fruit trees for *Anthonomus pomorum*, L., numbers of larvae of *Boriomyia nervosa*, Fab., were found spinning up in the bands. The numbers were such as to attract attention, and afforded an excellent opportunity for working out the life-history.

The cocoons were rather coarsely made, very loose; and in the mesh could be seen numerous oil-like globules. The larvae lay in a characteristic curved position in the cocoons with the head bent forward until it rested on the underside of the thoracic segments, the legs being slightly folded inwards. They remained quiescent in the cocoons until the spring of 1922, when many specimens pupated in March.

The pupa was quiescent in the cocoon. Its wings and legs were folded compactly and swathed in a membranous skin. The legs were whitish yellow, the head pale brown with distinctly darker eyes, and the wings yellowish. About three days before emergence the wings grew darker, the eyes assumed a purple coloration, and the head became brown and chitinous, with the powerful jaws readily distinguishable. The pupal stage lasted fourteen days. At emergence the pupal skin split and the insect proceeded to cut a way out of the cocoon and completed its emergence outside, where the pupal coat was shed.

The adult has mottled wings, of which the predominating colours are greens and browns with here and there black patches; there is a complicated system of nervures. The body is dark brown and the legs yellowish. The total length of the insect, including the antennae, which are long, slender and yellowish, is from eleven to twelve millimetres. The wings are usually supported roof-like over the body. The adults are sluggish during the day-time, resting in curled leaves or on the underside of leaves, but towards dusk they become active and can be seen taking short flights about trees. After emerging the adults feed voraciously on Aphids, and in due course mating takes place. In captivity eggs are laid twenty days after emergence. The life of the adult varied from twenty-three to twenty-five days.

The eggs were laid singly on the undersides of leaves, near the veins, or on the dead bodies of Aphids that were adhering to the leaves. They were at first white and elliptical; the surface was evenly reticulated, and a small disc-shaped structure, the micropyle, was located at one end. The total length of the egg is 0.8 mm. This stage lasts from eight to ten days. By the end of the third day the eggs were mottled with faint pink traces and the eye-spots became pink. On the fourth day the limb streaks were more distinctly pink, and by the eighth day the general form of the developing larvae could be discerned. On hatching the young larva protruded its head and limbs outside the shell, and by spasmodic abdominal movements got partially free, extending its limbs at the same time. The larva kept its legs pressed against the shell, and as the body was drawn farther and farther out, it assumed the form of a horseshoe. Considerable difficulty seemed to be experienced in the escape from the shell.

On emergence the larvae were pale green in colour, as distinct from the brownish green of later instars. They were very active and soon commenced searching for food, the head being swayed from side to side in a peculiar manner as they ran about over the leaves. The jaws were very prominent and suctorial, and the larva, on locating an aphid, seized it with its jaws, which worked to and fro laterally as the juices were sucked from the victim. As the larva grew it was seen that its general

outline was somewhat spindle-shaped, the broadest portion being towards the posterior region of the thorax, from whence it tapered off both anteriorly and posteriorly. When walking the caudal portion was used after the manner of the anal suckers or prolegs in the case of the GEOMETRIDAE. The larval stage was of about fourteen days duration, during which time growth was very rapid, several moults taking place. The larvae did not cover themselves with the skins of their victims, as is the case with many other members of this genus, and were frequently seen to reject their prey in a half-sucked condition. They showed a distinct preference for Aphids in the younger stages, devouring them very greedily. When mature the larvae became quiescent for a time, resting in bark crevices or curled leaves. Finally rough loose cocoons were spun and pupation took place.

In captivity the first brood pupated by 3rd May; and as the life-cycle requires about sixty-five days, it is probable that there are at least two broods per annum. Moznette (1) states that development takes place much more rapidly in warm temperatures; thus in hot dry seasons there may be as many as three broods, the last brood spinning up in October.

Several parasites were reared from the larvae of *Boriomyia nervosa*. They were ectoparasitic, the eggs being apparently laid in the host cocoon in the autumn before the larva pupated. The parasitic larvae hatched and fed on the host until spring, when they pupated, without spinning, inside the *Boriomyia* cocoons. The species reared were forwarded to Dr. J. Waterson, of the British Museum, who referred them to two Cynipid genera, *Aegilips* and *Anacharis*. The species of *Aegilips* was *A. fumipennis* (Weston). There were two species of *Anacharis*, *A. ensifer* and *A. eucharoides* (Hal.); the former has been previously noted (2), but the latter is apparently a new record.

References.

1. MOZNETTE. Second Crop Pest Report, Oregon Agric. College, 1915.
2. HANDLIRSCH. Verh. z-b. Ges. Wein, xxxvi, pp. 235-237.

NOTES ON THE NOMENCLATURE OF AUSTRALIAN TABANIDAE : SUBFAMILY PANGONIINAE.

By EUSTACE W. FERGUSON, M.B., Ch.M. (Syd.).

I. On the Subgeneric Divisions of *Pangonia* proposed by Walker (1850).

The question of the proper allocation of the subgeneric names introduced by Walker (Insect. Saund. Dipt. i, 1850) for the division of the genus *Pangonia*, Latr., appears never to have been entirely or satisfactorily settled.

In his work Walker subdivided *Pangonia* into 15 subgenera, for which he proposed the names *Nuceria*, *Fidena*, *Dicrania*, *Melpia*, *Scaptia*, *Pangonia*, *Tacina*, *Phara*, *Clanis*, *Osca*, *Philoliche*, *Scione*, *Plinthina*, *Scaphia* and *Lilaea*. Three of these names (*Dicrania*, *Pangonia*, and *Philoliche*) were, however, adopted from previous authors. Three of the names (*Dicrania*, *Pangonia*, and *Scione*) have been utilized since that date, though in the case of *Dicrania* the name of the genus has recently been altered to *Elaphella*, while Walker used the name *Pangonia* for a group of the genus (*sens. lat.*) in which the type species was not included.

In 1864 Rondani (Arch. Zool. Nat. Fisiol., iii, 1864, p. 83) subdivided the genus *Pangonia*, Latr. (originally spelled *Pangonius*) into two, *Pangonia* and *Diatomineura*, and further subdivided these genera into subgenera, *Pangonia* and *Erephopsis* in the case of *Pangonia*, and *Diatomineura* and *Corizoneura* in the case of *Diatomineura*.

That Rondani did not overlook the subdivision made by Walker is shown by his remark "Per le differenze che presentano le altre specie, il Walker ha proposto la formazione di quattordici sottogeneri nominati, oltre alla *Dichrania*, ma la maggior parte di essi non è accettabile per insufficienza di caratteri distintivi." Rondani's opinion that Walker's subgenera were not acceptable was adopted by subsequent writers until recently, and Rondani's classification was followed, though admittedly unsatisfactory and imperfect.

In 1914 the first move in this direction of the recognition of Walker's names was made by Brèthes (Bull. Soc. Ent. France, 1914, i, p. 59), who showed that the genotype of *Osca* was the same as the genotype of *Diatomineura*, selecting the first species mentioned by the authors of these genera as the genotype.

Austen in 1921 (Bull. Ent. Res., xi, pt. 2, p. 139) accepted the replacement of *Osca*, Walker, for *Diatomineura*, Rondani, and erected Rondani's subgenus *Corizoneura* into a genus, which he redefined, while he also described a new genus *Buplex*. At the same time Austen proposed that *Phara*, Walker, be substituted for *Cadicera*, Macquart, as the first three species listed by Walker under *Phara* certainly belonged to *Cadicera*. The remaining names introduced by Walker were, however, not settled.

Surcouf (Wytzman's Genera Insectorum, Fasc. 175, 1921) dealt with the Walkerian subgenera, but did not recognise them as valid. Thus he did not adopt the substitution of *Osca* for *Diatomineura* or that of *Phara* for *Cadicera*; Austen's new genus *Buplex* was admitted, but many of the old described species were still left under *Corizoneura*, though they did not conform to the characters laid down by Austen when redefining the genus.

The other subgeneric names proposed by Walker are listed by Surcouf under the generally accepted genera as synonyms, though in most cases Walker's names antedate those usually accepted. The position was, of course, complicated by the fact that the characters given by Walker for the subgenera were often only specific in value, and species listed by him in one subgenus might under the modern classification belong to two or more genera.

Probably the best solution would have been to disregard Walker's names completely, but this seems now impossible, partly because they are validly proposed notwithstand-

ing the unsatisfactory characters of the subgenera, and partly because the revival of two of these names by Brèthes and Austen cannot be disregarded.

As the question affects the position of the majority of Australian species of the subfamily PANGONIINAE, I have in this paper endeavoured to fix the status of Walker's names, so far as seems possible at the present moment, with the knowledge I possess and the material available. In so doing I have tried to avoid the introduction of unnecessary confusion, and in the selection of genotypes for Walker's subgenera I have not felt compelled to select the first species listed by Walker.

In the rather limited literature available in Australia I cannot find that, prior to Brèthes and Austen, any author in dealing with the subgenera proposed by Rondani has noted the genotypes, while they are also omitted from these genera in Surcouf's Monograph. The type of *Pangonia* (more correctly *Pangonius*), Latreille, has been designated as *P. proboscoides*, F., = *P. maculata*, F. The genotypes of *Diatomineura* and *Corizoneura* have been fixed by Brèthes and Austen respectively, these authors selecting the first species listed. Similarly for *Erephopsis* I select as genotype the first species mentioned—*P. margaritifera* = *E. guttata*, Don. (*Tabanus guttatus*, Don.).

For clearness in argument I have thought it wise to list the species quoted by Walker with the genera in which he placed them, and the generic names subsequently used by Rondani, Ricardo, Austen, and Surcouf. The reference made by Austen and Rondani to species on this list are few but important. (See Appendix.)

By the use of this list it is hoped that the discussion of the Walkerian names will be simplified. I propose to discuss these seriatim and in the order in which they were introduced by Walker.

Nuceria.

Five species are listed under this name, two of which are regarded by recent authors as species of *Corizoneura* and three as belonging to *Pangonius*. I propose to nominate the third species (*rostrata*) as genotype and to sink the genus as a synonym of *Pangonius* Latr. The selection of the first species as genotype in this case would probably invalidate *Corizoneura*; though I cannot be sure whether *P. longirostris*, Hardwick (*Corizoneura*) or *P. longirostris*, Macq. (*Erephopsis*) is intended.

Fidena.

All of the four species are included by Ricardo and Surcouf in *Erephopsis*. I have no knowledge from actual specimens of these species, but one (*nana*) is figured by Lutz (1911). The first species (*leucopogon*) is here selected as genotype, as there appears to be no reason against so doing. The status of this genus will be discussed later.

Dicrania.

This genus was originally proposed by Macquart (1834), the name being preoccupied has been changed by Bezzi (1913) to *Elaphella*.

Melpia.

Nine species are listed, of which eight are placed by Miss Ricardo in *Erephopsis* and one in *Diatomineura*. The number, however, is reduced by Surcouf, who quotes four as synonyms of *E. nigripennis*, Guér.; I therefore select the first mentioned (*rufohirta*, Walk., = *nigripennis*, Guér.) as genotype.

Scaptia.

This genus is of special interest to Australian workers, as all of the included species are Australian. The number (six) is, however, reduced to four by synonymy. The species are all included in the genus *Diatomineura*, Rondani. The first named species (*aurata*, Macq.) is here designated as genotype.

Pangonia.

The first three species are Australian and are included in *Erephopsis*, Rondani. The first (*guttata*, Don.) is indeed the same as the genotype (*margaritifera*, Walk.) of *Erephopsis*. The remaining species is a true *Pangonius*. The name *Pangonia* as used by Walker must be regarded as preoccupied by *Pangonius*, Latreille.

Tacina.

Three European species are included here, all belonging to the genus *Pangonius* (*sens. strict.*). The first (*micans*) is here designated as genotype, and the genus *Tacina* sinks as a synonym of *Pangonius*.

Phara.

The first species (*melanopyga*) has already been designated as genotype by Austen, and the genus used to replace *Cadicera*. The first three species belong to *Cadicera*; of the remainder ten are included in *Pangonius* by Surcouf, two in *Corizoneura* and three are not given in the lists of species under the different genera. One of the species (*barbata*) is placed by Austen under *Oscia*. In his note on *Phara*, Surcouf allots the species as follows:—three *Cadicera*, three *Corizoneura*, eleven *Pangonia* (three *sensu latiore*) and one *Diatomineura*.

Clanis.

Eighteen species are listed by Walker, mostly from Australia and New Zealand; eight of these are placed by Surcouf under *Erephopsis*, six in *Diatomineura*, two in *Pangonius*, and one in *Corizoneura*. One (*fulvifascia*) is placed by Austen in *Oscia*; one (*mediocris*) is not included in Ricardo's or Surcouf's list of species and is probably a *nomen nudum*. In his note on *Clanis*, however, Surcouf lists the species as follows:—nine *Erephopsis*, five *Diatomineura*, one *Corizoneura*, and three *incertae sedis*. The first named species (*contigua*) is here designated as genotype, and all the Australian species of *Erephopsis* should come under *Clanis*. The name, however, is preoccupied by *Clanis*, Hübner, 1816, in Lepidoptera.

Oscia.

Two species are included, the first (*depressa*, Walk., = *lata*, Guér.) has been designated by Brèthes as genotype, and *Oscia* used to replace *Diatomineura*, of which the same species is genotype.

Scione.

One species—*incompleta*. The same species was utilised by Schiner as the type of *Diclisia*, hence the latter name must be regarded as an absolute synonym of *Scione*, and cannot be revived as has been done by Surcouf for a separate genus.

Plinthina.

One species—*macroporum*. This species is included in *Erephopsis* by later authors. *E. binotata* (= *E. macroporum*) is one of the most distinct of the Australian species of the genus, although *E. clelandi*, *E. divisa* and *E. cinerea* are closely allied. It may be necessary in the future to revive *Plinthina* for this group.

Scarphia.

The only species (*directa*) was placed by Ricardo in *Corizoneura*, and had this determination still stood, it would be necessary to replace *Corizoneura* by *Scarphia*. In a recent paper, however, *directa* is regarded by Miss Ricardo as conspecific with *P. parva*, Walk., for which a new genus *Metoponaplos* is erected (Ricardo, Ann. S. African

Museum, London, xvii, no. 6, 1920). If *directa* is really synonymous with *parva*, Walker's genus *Scarphia* will replace *Metoponaplos*. Miss Ricardo's phrase "with which *Pangonia directa* appears to be identical" would indicate that there was some doubt on the matter.

Lilaea.

Two Australian species are listed. The first (*roeti*) has not been recognised in recent collections; I therefore designate the second species (*lurida*) as genotype. This species is placed by modern authorities in *Silvius*, which antedates *Lilaea*. The latter name therefore falls into synonymy.

Philoliche.

Five species listed, four belonging to the genus *Pangonius*, and one to *Diatomineura*. The name *Philoliche* was, however, used prior to Walker by Hoffmannsegg (1828), in Wiedmann's *Aussereurop Zweifl. Ins.* i, p. 95, and is placed as a definite synonym of *Pangonius* in Surcouf's Monograph.

The relation of the Walkerian names, as detailed above, to the commonly accepted genera would thus appear to be as follows:—

Pangonius—*Nuceria*, *Tacina*, *Philoliche*.
Erephopsis—*Fidena*, *Melpia*, *Pangonia*, *Clanis*, *Plinthina*.
Diatomineura—*Scaptia*, *Osca*.
Silvius—*Lilaea*.
Cadicera—*Phara*.
Metoponaplos—*Scarphia*.
Elaphella—*Dicrania* (nom. praeocc).
Scione—*Scione*.

In the case of the names allotted to *Pangonius*, *Silvius*, *Elaphella* and *Scione*, no change is involved. *Phara*, however, replaces *Cadicera*, and *Scarphia* in all probability should replace *Metoponaplos*.

This leaves for further consideration the names placed under *Erephopsis* and *Diatomineura*, since *Corizoneura* is not involved in the changes.

As shown by Brèthes and Austen, *Osca* must replace *Diatomineura*, as the genotype of both genera is the same. It is, however, another question as to whether *Osca* is to replace *Diatomineura* for all the species referred to this genus. Though placed by Rondani among the species with the first posterior cell open (*Diatomineura*), other authors have included *Pangonia depressa*, Macq., in *Erephopsis*, and the species is still included in *Erephopsis* in Surcouf's Monograph.

The question therefore arises as to the relation of *Osca* to *Erephopsis*. The trouble appears to be that *O. lata* is one of those species in which the closure of the first posterior cell is variable. This character is a most unsatisfactory one for generic purposes. The second character used by Rondani in subdividing both *Pangonia* and *Diatomineura*, that is to say, the bare or hairy eyes, is a much more satisfactory one, and might well have been employed as the primary division. By its use one might divide *Pangonia* into two groups—*Pangonius* and *Corizoneura* with bare eyes, and *Diatomineura* and *Erephopsis* with hairy eyes. This subdivision is more in keeping with the geographical distribution of the group, *Pangonia* and *Corizoneura* predominating in Europe, Africa, and Asia, while *Diatomineura* and *Erephopsis* are most abundant in America and Australia.

The further differentiation into genera on the character of the first posterior cell appears to me quite unjustifiable, even with a qualifying statement such as "generally open" or "closed as a rule." In Australian species, at any rate, this

character is highly variable, and I have found that in species in which the cell is habitually closed, an examination of a sufficiently long series will disclose the existence of individuals in which this cell is open. The converse is also true; for example, out of 70 specimens of *Diatomineura ruficornis*, Macq., which were examined, five were found with the cell closed. Furthermore, there are numerous species in which the cell is so variable that it is well nigh impossible to say to which group they belong.

It does not necessarily follow from this, however, that all the hairy-eyed species included in *Erephopsis* and *Diatomineura* are congeneric. So far as the Australian species are concerned, careful examination of the great majority of those described has failed to reveal characters which will separate them generically, with the possible exception of the small groups of species allied to *E. binotata*, Latr., which might be separated subgenerically.

Examination of specimens and figures of South American species included under *Erephopsis* has shown that many of the species from that continent are not congeneric with Australian species. The differences lie in the face and the proboscis. In the South American species such as *E. ardens*, Macq., the face is greatly produced in front, while the labella are not dilated but of equal width with the proboscis generally (fig. 1, b). In all the Australian species the face is not advanced, and the labella are distinctly broader than the general width of the proboscis (fig. 1, a). I do not know whether intermediate forms occur among South American species, but certainly all the Australian species examined are constant in this respect. The question thus arises as to what generic names are to be applied to these genera, and it will be necessary to examine the names used by Walker in this connection.

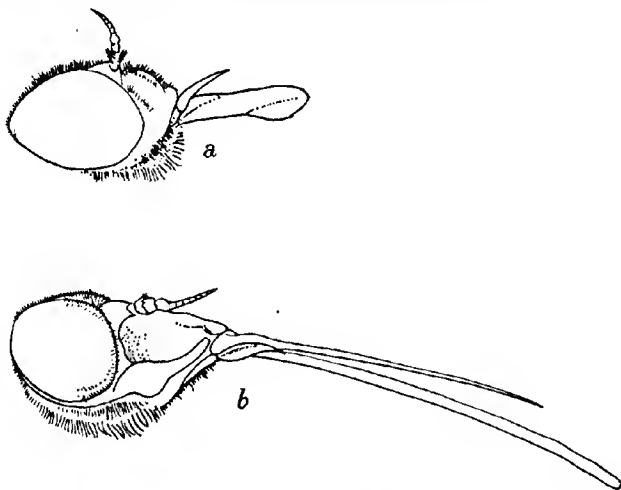


Fig. 1. Head and proboscis of: (a) *Osa limbithorax*, Macq., from Kendal, New South Wales; (b) *Pangonia* (s.l.) *ardens*, Macq., from S. Paulo, Brazil.

Fidena includes four South American species, of none of which are specimens available here, and the description of the genotype (*leucopogon*, Wied.) does not mention the characters of the face and labella. The figure of *Erephopsis nana*, however, given by Lutz (Mem. Instit. Oswaldo Cruz, iii, 1911, pl. iv, fig. 2) shows the strongly advanced face and thin labella characteristic of many South American species of *Erephopsis*. If this is true likewise of *leucopogon*, *Fidena* might be used to

replace *Erephopsis* for South American species with these characters. It is to be noted, however, that *nana* differs from most South American species, according to Lutz, in the first posterior cell being closed far from the wing border.

Melpia is also founded on South American species of *Erephopsis*, and more definite information is available as to the structure of the genotype *E. nigripennis*, Guér., as the advanced face is mentioned by Miss Ricardo (1900) in her notes on *E. nigrohirta*, Walker—a synonym of *E. nigripennis*. The genus *Melpia* might therefore have been taken as applying to the same group of species as *Fidena* but for a note by Surcouf (1921) given in his remarks on *Bombylomyia* (p. 117). "*Pangonia nigripennis* Guérin (1832) et ses nombreux synonymes offrent tous les caractères de *Bombylomyia* Lutz, sauf celui de la face lisse et brillante: cette partie est en effect revêtue d'une pulvéulence grise qui la recouvre en entier." While I should doubt the generic value of this character, the question of the relation of *Melpia* to *Fidena* and to *Bombylomyia* must be left to entomologists better acquainted with South American species. At any rate Australian species do not appear to be affected by these names.

Osca was formed for two South American species; Austen (1921) includes two African species in the same genus. In a private letter Major Austen also states that *P. limbithorax*, Macq. (1885), described from an unknown locality, is congeneric with *Osca lata*, Guér., the type species. As will be shown later, *Osca limbithorax*, as it must now be known, is an Australian species. Examination of this species shows that the face is not produced and the labella are wider than the rest of the proboscis. The genus *Osca* must therefore be regarded as distinct from the group of species included in *Fidena*, *Melpia* and *Bombylomyia*.

As stated above, all the Australian species grouped under *Erephopsis* and *Diatominera* agree in the characters of the face and rostrum. Four names are used by Walker of which the genotypes as defined above are Australian species; of these names *Pangonia* and *Clanis* must be discarded as preoccupied, the remaining two (*Scaptia* and *Plinthina*) are available. Comparison of *Osca limbithorax* with other species reveals no reason why they should be separated generically from *Osca*, and this name as already selected by Brèthes must take precedence over *Scaptia*, and should be used for all the Australian species.

Plinthina might be regarded as a subgenus of *Osca*, the points of distinction being the short first posterior cell, which is closed far from the border, to which it is connected by a long stem, the large and conspicuous stigma and the coloration of the wings, the cells being dark in the centre and light along the edges. The species included in the subgenus are *Pangonia binotata*, Latr. (= *P. macroporum*, Macq.), *Pangonia divisa*, Walk., *Erephopsis cinerea*, Ric., and *E. clelandi*, Ferg.

In the above review I have dealt practically entirely with the genera comprised in the hairy-eyed section of *Pangonia* (*sens. lat.*). It may, however, be possible to divide the bare-eyed section into genera on similar characters, and the question may arise as to whether any other of Walker's names here sunk as synonyms of *Pangonius* should be resurrected. Austen has already employed the prolongation of the face as one of the characters separating *Corizoneura* from *Buplex*. The few Australian species that have been included in *Corizoneura* do not agree with that genus as redefined by Austen, but correspond with his new genus *Buplex*. Until further evidence is forthcoming I propose therefore to consider our Australian species as belonging to the latter genus.

Pangonius (*sens. strict.*) does not occur in Australia.

Scione appears on the Australian list with one species, *S. singularis*, Macq. (1846), but it has not been identified by recent writers. I believe that *S. singularis* will prove identical with *Osca* (*Pangonia*) *submacula*, Walk., which agrees with the description of *S. singularis* given by Macquart, though the figure shows the wings more darkly shaded than is the case in any of the specimens of *O. submacula* that I have seen. Walker's species is represented in the Macleay Museum, Sydney, under the

name of *S. singularis*, Macq. As noted by Ricardo (Ann. Mag. Nat. Hist. (7) v, p. 115, 1900), the species is too closely related to *O. guttata* to be separated generically, while in the latter species the fourth posterior cell is narrowed at the apex and may be actually closed. If this determination be correct Macquart's name will have priority.

II. *Notes on the Determination of some of the early described Australian Tabanidae (Subfamily Pangoniinae).*

***Oscia lasiophthalma*, Macq.**

"*Pangonie fuligineuse*," Boisd., Voy. de l'Astrolabe, Entom., pl. xii, fig. 13 (1832).

Pangonia lasiophthalma, Macq., Hist. Nat. Dipt. i, p. 193 (1834); Boisd., Voy. de l'Astrolabe, Entom., ii, p. 666, (1835); Walker, List Dipt. Brit. Mus. v, Suppl. 1, p. 139 (1854); Wulp, Cat. Dipt. S. Asia (1896); Ricardo, Ann. Mag. Nat. Hist. (7) v, p. 114 (1900).

Erephopsis lasiophthalma, Boisd., Ricardo, Ann. Mag. Nat. Hist. (8) xix, p. 210 (1917).

Pangonia contigua, Walk., List. Dipt. Brit. Mus. i, p. 138 (1848).

Pangonia fuliginosa, Walk., *op. cit.*, v, Suppl. 1, p. 140 (1854)—quoted as of Boisdual, Voy. de l'Astrolabe, Ent. Dipt. pl. xii, fig. 13.

Pangonia maculipennis, Macq., Dipt. Exot. Suppl. iv, p. 20 (1850); Schiner, Reise Novara, Dipt., p. 99 (1868).

Erephopsis maculipennis, Macq., Ricardo, Ann. Mag. Nat. Hist. (7) v, p. 106 (1900) and (8) xvi, p. 23 (1915).

Concerning this species Miss Ricardo (*l.c.* 1917) writes as follows:—"The type was described from Cape Jervis, S. Australia. *Erephopsis contigua*, Walk., is not identical as Walker stated. *Pangonia fuligineuse*, Boisdual, is from New Guinea; whether it is the same as *Erephopsis lasiophthalma* is doubtful."

In the same place Miss Ricardo identifies the species with an insect that occurs in the south of New South Wales and in Victoria. With this identification I cannot concur, as both the figure and the description indicate that the species described by Boisdual has two distinct bands on the wings; whereas the species identified as *lasiophthalma*, Boisd., by Ricardo has only a band at the base of the discal cell, and the description of the abdomen does not agree. The species appears first as a figure (No. 13) on plate xii of the illustrations of the Faune Entomologique of the Voyage de l'Astrolabe. The date of publication of these plates is given by Sherborn and Woodward (Ann. Mag. Nat. Hist. (7) viii, p. 333, 1907) as 1832,* though the wrapper is dated 1833. The name of the insect is given under the plate as: 13, *Pangonie fuligineuse* Boisd. (Nouv. Hollande). This name cannot be regarded as a properly proposed scientific name, being a suggested popular name, nor can it be regarded as a French translation of the name—*lasiophthalma*—subsequently proposed. The locality (Nouv. Hollande) is not in accord with Miss Ricardo's statement quoted above. The text of the Faune Entomologique, Part ii, in which the species was described, appeared in 1835, and the name is given as *Pangonia lasiophthalma*, Meigen, the name "*Pangonia fuligineuse*" being quoted as a reference to the figure.

In the meantime, however, the name *Pangonia lasiophthalma* had been already proposed by Macquart (1834) for a species stated to be "De la Nouvelle-Guinée, rapportée par le capitaine d'Urville." As d'Urville was the commanding officer of the Astrolabe Expedition, the question arises as to whether the species named by Macquart, whose name would of course have priority, is the same as the species described by Boisdual. The descriptions are not identical, but are complementary

* "The first livraison was received by the Soc. Ent. Fr. 4 April, 1832, and seems to have been plates only" (Sherborn & Woodward, *loc. cit.*).

and not contradictory, but if the localities given are correct, it is extremely unlikely that the species are the same. I believe, however, that a mistake has occurred in both the localities quoted. The locality given by Boisduval was Cape Jervis, and has been assumed to refer to Cape Jervis in South Australia. But reference to the charts and narrative of the voyage show that the "Astrolabe" was not in the vicinity of Cape Jervis, but passed directly from King George Sound to Western Port in Victoria. On the other hand, the vessel was forced by adverse winds to anchor in Jervis Bay in New South Wales, where several days were spent. If it can thus be assumed that Cape Jervis is really Jervis Bay, the question of the identity of at least Boisduval's species becomes clearer; this question will be considered later.

My reasons for doubting the locality Nouvelle Guinée, quoted by Macquart for his species, are principally based on the rarity of the group in that country. So far as I can trace, apart from *P. lasiophthalma*, Macq., only two species have been described from New Guinea (*Diatomineura caliginosa*, Walk., and *Erephopsis novae-guineensis*, Ric.), whereas in Australia the group is abundantly represented. The point can only be settled by the discovery and examination of the types, if they still exist.

Walker quoted the name *Pangonia lasiophthalma* as of Macquart, giving New Guinea as the habitat, and quoted Boisduval's species as *Pangonia fuliginosa*—a translation of the French name given to the figure. At the same time he placed *P. contigua*, Walk., under *Pangonia fuliginosa* as a synonym.

The identity of *P. contigua* with *P. lasiophthalma*, Boisd., has been questioned by Miss Ricardo, and certainly it is not conspecific with the species identified by Miss Ricardo as *lasiophthalma*. I believe, however, that Walker was right in his determination, as both description and figure accord better with *E. contigua* than with the species identified by Miss Ricardo. The locality—Jervis Bay—is also in keeping, as I have seen specimens of *E. contigua* from Kialoa, a short distance to the south of Jervis Bay, while the range extends northward at least as far as Camden Haven. If, as I suggest, the locality New Guinea given by Macquart, is a mistake for New Holland, the species should bear the name *Oscia lasiophthalma*, Macq. If Macquart's species ultimately proves distinct, the name *Oscia contigua*, Walk., must be used.

In the synonymy given under this species I have also included the name of *Pangonia maculipennis*, Macq. (1850). In this determination I am again at variance with Miss Ricardo. *Pangonia maculipennis* was described from the East Coast of Australia, and Schiner (1868) records a specimen from Sydney. Both of the authors describe the wings as possessing two bands, and for this reason I cannot accept the determination made by Miss Ricardo (Ann. Mag. Nat. Hist. (8) xix, 1917, p. 209) of a South Australian insect as this species. Miss Ricardo herself was in doubt about the identification. I have also seen the name attached to specimens of *Oscia quadrimacula* in Australian collections. This latter species differs from Macquart's description in the coloration of both thorax and abdomen. The description, however, agrees well with *P. contigua*, Walk., except in one point. Both Macquart and Schiner refer to the presence of a rudimentary appendix on the fork of the third longitudinal vein. This is not present in the four specimens now available for examination, but as this is often variable within a species, I do not think that too much stress should be laid upon it. The identification of *P. maculipennis* with *P. contigua* would also accord with the habitat of the latter.

***Oscia maculiventris*, Westw.**

Pangonia maculiventris, Westwood, London and Edinburgh Phil. Mag. (3) vi, p. 449 (1835); Ricardo, Ann. Mag. Nat. Hist. (7) v, p. 114 (1900).

Pangonia jacksoni, Macq., Dipt. Exot. i, p. 102 (1838); Walker, List Dipt. Brit. Mus. i, p. 140 (1848), and Ins. Saund. Dipt. i, p. 15 (1850).

Erephopsis jacksoni, Macq., Ricardo, Ann. Mag. Nat. Hist. (7) v, pp. 112, 117 (1900).

Westwood's species was not identified by Miss Ricardo in her revision of the Australian species of PANGONIINAE. The short but clear description, however, agrees perfectly with the insect identified by Miss Ricardo as *Erephopsis lasiophthalma*, Boisd. I have given reasons above for thinking that this species is not the one described by Boisdual, and I think it would be better to refer to the species as *Osca maculiventris*, Westw.

The description of *Pangonia jacksoni*, Macq. (1838) also agrees with the one identified above as *Osca maculiventris*. The species is variable in the number of spots on the abdomen; sometimes these are only present on the second and third segments, the other segments being banded; in other specimens the band on the fourth segment is reduced to a spot, and sometimes the bands are reduced on all the segments. *P. jacksoni* was described as having spots on the second, third and fourth segments. The single band on the wing is not noted by Macquart, as the wings were mutilated in the type; Miss Ricardo, however, states that the cross-veins are shaded. As, however, she records the species from Western Australia the identification is open to question. The species described by me as *Erephopsis xanthophilis* has also been thought to be *P. jacksoni*. *E. xanthophilis* differs from the description of *P. jacksoni* in having the apical abdominal segments all black, and not merely black along the anterior half; no mention is made by Macquart of the rich golden pubescence on the thorax and pleurae, which could hardly have escaped his notice. There is a specimen in the Paris Museum labelled *Pangonia jacksoni*, Macq., of which I have merely a short note:—"Very close to, if not *D. constans*—Tasmania." I doubt, however, if this is the type. The first posterior cell is variable, being sometimes open and sometimes closed, generally in the border.

***Osca guttipennis*, sp.n.**

Erephopsis maculipennis, Ric., Ann. Mag. Nat. Hist. (8) xvi, p. 23 (1915)—nec *Pangonia maculipennis*, Macq., Dipt. Exot. Suppl. iv, p. 20 (1850).

General colour black, abdomen yellowish brown at base and on segmentations; wings maculate on cross-veins.

Face dark, densely clothed with dark grey tomentum, with rather sparse long brownish pubescence with some paler hairs intermingled; beard dense, pale creamy. Palpi reddish brown, the first joint and lower border darker; first joint clothed beneath with long creamy hairs; second joint longer than first but comparatively short, moderately broad, briefly pointed, the outer surface with a deep longitudinal depression, looking somewhat upwards as well as outwards, the edges slightly inverted. Proboscis long, over twice as long as head. Antennae with basal joint black with long black hairs, second joint short, variable in colour, reddish brown or black, with very long black hairs, third joint reddish, the basal portion wider than rest of annuli. Forehead broader anteriorly than at vertex, black, with yellowish brown tomentum anteriorly, extending on to the subcallus, with grey tomentum laterally and above; pubescence black, with long hairs behind ocelli; a somewhat irregular laevigate area present in anterior third. Eyes finely faceted, densely pubescent, the hairs whitish over lower portion, dark brown above.

Thorax black, covered with brown tomentum with five narrow hoary grey longitudinal lines, the submedian and lateral united by an oblique line, the median not extending beyond middle, lateral margins with tufts of black hair in front, and creamy white above wing roots and at sides of scutellum; pleurae with slaty grey tomentum and long creamy white hair-tufts. Scutellum black, with brown tomentum.

Abdomen with first and second segments yellowish brown, with a black transverse macule on first behind scutellum and a black subquadrate macule on second segment not extending to posterior margin; remaining segments black with moderately broad yellowish brown segmentations; pubescence black, with small median creamy

white flecks on the posterior borders of the second to fifth segments; lateral margins with creamy white pubescence at the postero-lateral angles of all the segments extending for a short distance along the posterior margins. Venter yellow.

Legs black, the tibiae and tarsi reddish brown, the tarsi infusate at the apices of the segments. Wings grey, with cross-veins shaded with brown, most marked at base of discal and marginal cells, at apex of discal cell and bifurcation of third longitudinal vein; first posterior cell closed; third longitudinal vein with a short recurrent appendix at bifurcation.

Length, 15 mm. (exclusive of proboscis); proboscis, 6 mm.; a second female 12 mm.

SOUTH AUSTRALIA: Port Lincoln; Yeelanna. WESTERN AUSTRALIA: Mundaring. Type in South Australian Museum.

The above description is based on material that Miss Ricardo had under examination and determined as *Erephopsis maculipennis*, Macq., though admitting there were several discrepancies. After carefully considering Macquart's description I cannot regard it as applying to the present species. *O. guttipennis* is closely allied to *O. gemina*, Walker, but differs in the palpi, which are very slightly concave on the outer surface in the latter species. The general coloration is darker in *O. gemina*, the base of the abdomen and segmentations being more of a reddish brown; the femora also are not wholly black, while the shading of the cross-veins of the wings is less pronounced.

Two specimens from Ashford, in New South Wales, possibly represent a variety; the wings being only slightly shaded at the base of the discal and marginal cells, the palpi are, however, as in *O. guttipennis* and not as in *O. gemina*.

***Osca limbithorax*, Macq.**

Pangonia limbithorax, Macquart, Dipt. Exot. Suppl. v, p. 22 (1855).

Erephopsis niveovittata, Ferg. & Henry, Proc. Linn. Soc. N. S. Wales, xlv, p. 838 (1919).

This species was described by Macquart from an unknown locality. As the description appeared to agree rather closely with *Erephopsis niveovittata*, Ferg. & Henry, a specimen of the latter was sent to Major Austen for comparison with the type. Unfortunately the box containing the specimen was delayed in delivery through detachment of the label in the post. Major Austen therefore answered my queries without having seen the specimen.

"*P. limbithorax* belongs to the genus *Osca*, Walker In general facies, as distinct from the coloration of the hair on the lateral margins of the dorsum of the thorax and on the distal extremity of the abdomen, *Osca limbithorax*, Macq., strongly resembles the genotype *O. lala* (*Tabanus latus*), Guér., so that I think it quite possible that the former is not Australian at all, but S. American like the latter."

Later, on receipt of the specimen Major Austen wrote again:—

"In spite of the doubt expressed in my letter of March 16th as to whether *Osca* (*Pangonia*) *limbithorax*, Macq., is really an Australian species, a comparison of the specimen of *Erephopsis niveovittatus*, Ferg. & Henry, sent by you with the type of the former shows that the two are certainly conspecific."

***Osca bicolor*, Macq.**

Pangonia bicolor, Macquart, Dipt. Exot. Suppl. i, p. 24 (1846).

Erephopsis bicolor, Macq., Ricardo, Ann. Mag. Nat. Hist. (7) v, p. 112 (1900).

The description of this species, which was not identified by Miss Ricardo, differs from *Osca maculiventris*, Westw., only in the description of the wings, there being no

mention of the band-like clouding at the base of the discal and marginal cells. The species may therefore be distinct. I cannot, however, otherwise identify it among the species known to me.

***Oscia dorsomaculata*, Macq.**

Pangonia dorsomaculata, Macquart, Dipt. Exot. Suppl. iv, p. 22 (1850).

Dialomineura dorsomaculata, Macq., Ricardo, Ann. Mag. Nat. Hist. (7) v, p. 113 (1900).

This species, which was founded on a male, I have been unable to identify. The habitat (Tasmania) given by Macquart is to be doubted, as in the case of other species described from Tasmania it is now known that they do not occur on that island, but are found in the coastal districts of New South Wales or in Queensland.

***Oscia aurata*, Macq.**

Pangonia aurata, Macquart, Dipt. Exot. i, p. 100 (1838).

Pangonia albicostata, Macq., Dipt. Exot. Suppl. i, p. 24 (1846).

Pangonia crassa, Walker, List Dipt. Brit. Mus. i. p. 144 (1848).

Miss Ricardo placed these three specific names under *Dialomineura* in her revision (1900). Later (1915) she recorded the synonymy of *D. crassa* with *D. aurata*. I believe that *Pangonia albicostata* should also be included in the synonymy.

Specimens are before me which were compared with the type of *P. crassa*, and I have compared these with descriptions of *P. aurata* and *P. albicostata*. The descriptions differ slightly in the colour of the clothing, but the series of *P. crassa* shows that these apparent differences are not constant, but vary with individual specimens.

APPENDIX.

Table showing the Genera in which the species of Pangoniinae mentioned by Walker have been placed by various Authors.

Species.	Walker.	Ricardo.	Austen.	Surcouf.	Rondani.	Loc.
longirostris	Nuceria	Corizoneura	Corizoneura	Corizoneura	Erephopsis	Asia
amboinensis	"	Pangonia (Latr.)	—	Pangonius	—	"
rostrata	"	Pangonia	—	Pangonius	—	Africa
gulosa	"	"	—	"	—	"
varicolor	"	Corizoneura	Corizoneura	Corizoneura (=aethiopica, Thun.)	—	"
leucopogon	Fidena	Erephopsis	—	Erephopsis	Erephopsis	S. America
basalis	"	"	—	"	—	"
sorhens	"	"	—	"	—	"
nana	"	"	—	"	—	"
comprehensa	Dicrania	Dicrania	—	—	—	"
rufohirta	Melpia	Erephopsis	—	(=Erephopsis nigripennis, Guér.)	—	"
nigrohirta	"	"	—	(=E. nigripennis, Guér.)	—	"
fulvithorax	"	"	—	Erephopsis	Erephopsis	"
piceohirta	"	"	—	(=E. nigripennis, Guér.)	—	"
badia	"	"	—	"	—	"
eriomera	"	"	—	Bombylo-myia, subg. Erephopsis	—	"
besckii	"	"	—	Diatomin-eura	—	"
exeuns	"	Diatomin-eura	—	Diatomin-eura	—	"
tenuistria	"	Erephopsis	—	—	—	"
aurata	Scaptia	Diatomin-eura	—	Diatomin-eura	—	Australia
auriflua	"	" eura	—	" eura	—	"
solida	"	(=auriflua)	—	(=auriflua)	—	"
patula	"	"	—	Diatomin-eura	—	"
plana	"	"	—	" eura	—	"
crassa	"	"	—	"	—	"
guttata	"	(=aurata)	—	(=aurata)	—	"
media	Pangonia	Erephopsis	—	Erephopsis	—	"
submacula	"	"	—	"	—	"
marginata	"	Pangonia	—	Pangonius	—	"
micans	Tacina	"	—	"	—	Europe
maculata	"	"	—	"	—	"
ferruginea	"	"	—	"	—	"
melanopyga	Phara	Cadicera	Cadicera	Cadicera	—	Africa
chrysostigma	"	"	"	"	—	"
crassipalpis	"	"	"	"	—	"
lateralis	"	Corizoneura	Corizoneura	Corizoneura	—	"
varicolor	"	?	—	Pangonius	—	"
angulata	"	Pangonia	—	"	—	"
multifaria	"	—	—	"	—	"
spiloptera	"	Pangonia (Latr.)	—	"	Pangonia	"
atricornis	"	Pangonia	—	"	—	"
cingulata	"	"	—	Pangonius	—	"
alboatra	"	"	—	—	—	"
obesa	"	"	—	—	—	"
adjuncta	"	"	—	Pangonius	—	"
conjuncta	"	"	—	Pangonius (=angulata)	—	"

APPENDIX—Continued.

Species.	Walker.	Ricardo.	Austen.	Surcouf.	Rondani.	Loc.
barbata	Phara	Diatomin-eura	Osca	Corizoneura	—	Africa
leucomelas	"	Pangonia (Latr.)	—	—	—	"
sexfasciata	"	Pangonia	—	Pangonius	—	"
bifasciata	Clanis	Erephopsis	—	Erephopsis	—	Australia
contigua	"	?	—	Pangonius	—	Loc. ?
inconspicua	"	Erephopsis	—	Erephopsis	—	Australia
gemina	"	"	—	"	—	"
quadrinacula	"	"	—	"	—	S. America
winthemi	"	"	—	Diatomin-eura	—	Australia
jacksoni	"	"	—	"	—	"
concolor	"	Diatomin-eura	—	"	—	"
constans	"	"	—	Diatomin-eura (= ruficornis)	—	"
mediocris	"	—	—	—	—	?
lerda	"	Diatomin-eura	—	Diatomin-eura	—	N. Zealand
adrel	"	Erephopsis	—	Erephopsis	—	"
divisa	"	"	—	"	—	Australia
fulvifascia	"	Pangonia	Osca	Diatomin-eura	—	Africa
tricolor	"	Erephopsis	—	Erephopsis	—	Australia
gemella	"	Diatomin-eura	—	Diatomin-eura	—	"
conjungens	"	Pangonia (Latr.)	—	Pangonius	—	"
gibbula	"	Erephopsis	—	Erephopsis	—	"
parva	"	Corizoneura	—	Corizoneura	—	Africa
fuscipennis	Philolice	Pangonia	—	Pangonius	Pangonia	S. America
notabilis	"	"	—	"	—	"
umbra	"	"	—	"	—	"
fusiformis	"	"	—	"	—	N. America
viridiventris	"	Diatomin-eura	—	Diatomin-eura	Diatomineura	S. America
depressa	Osca	Erephopsis	Osca	Erephopsis (= E. lata, Guér.)	"	"
albithorax	"	Diatomin-eura	—	Diatomin-eura	"	"
incompleta	Scione	Scione	—	Scione	—	"
macroporum	Plinthina	Erephopsis	—	Erephopsis	—	Australia
directa	Searphia	Corizoneura	—	Corizoneura	—	Africa
roei	Lilea	Pangonia (Latr.)	—	Pangonius	—	Australia
lurida	"	Silvius	—	?Pangonius	—	"

THE TRYPANOSOME INFECTIONS OF TSETSE-FLIES IN NORTHERN NIGERIA AND A NEW METHOD OF ESTIMATION.

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(Plates xxiii-xxv.)

	Page.
I. Introduction	265
II. Technique	268
1. The Full Dissection	268
2. Proboscis Dissection	268
3. Proboscis and Salivary Gland Dissection	268
III. Identification of Infections	272
IV. A Comparison of the Infectivity of the Prevalent Tsetse of N. Nigeria	276
V. <i>Trypanosoma grayi</i> in <i>Glossina palpalis</i> and <i>tachinoides</i>	279
VI. Estimation of Infection by Proboscis Examination	280
1. Seasonal Variation in Infection	280
2. Comparison of Infection in Various Areas	283
VII. Summary and Conclusion	284
VIII. Appendix. Transmission Experiments with <i>G. tachinoides</i>	285

I. INTRODUCTION.

The Tsetse Investigation in N. Nigeria is being carried out under the auspices of the Imperial Bureau of Entomology, the expense being met by the Nigerian Government. The work was commenced by the present Investigators in 1921 and their Report dealing with the first year's work was published in the Bulletin of Entomological Research (xiii, p. 373, April 1923). This paper deals more fully with the trypanosome infection of tsetse in Nigeria and describes a method of estimating this with rapidity.

In studying the relationship of tsetse-flies to the wild fauna a rapid method of estimating the trypanosome infections of the flies is of great utility. By means of it a knowledge of the relative importance of the various species as disease carriers can be obtained, especially when they are found ranging the same area, and it is possible to gain information about the source of the bulk of their food. Light is also thrown on important points in their bionomics, as for instance the very definite breeding seasons in the case of certain species and, as will be shown, their range of flight.

The various Commissions which have been engaged in the study of the tsetse-borne trypanosomiasis and their method of conveyance rather than in that of the bionomics of the carrier have generally relied on the method of feeding freshly caught flies in large numbers on experimental animals and have arrived at a rough estimate of their infectivity by this means. This is, of course, the only method which would serve their main purposes, and the proportion of infective to non-infective flies is arrived at quite incidentally. The estimates of the infectivity of *G. morsitans* thus obtained by the Royal Society's Commission in Nyasaland (1) and the Luangwa Sleeping Sickness Commission (2) are given in Table I. for comparison with our own figures recorded below. In this method of estimation there are several untoward factors which reduce the value of the statistics. In the large batches of flies which are necessarily used there may be a number infective with the same trypanosome, but this number however large can only be recorded as one. Secondly, the varying resistance of individual experimental animals introduces an error which cannot be avoided. The considerable resistance of the smaller experimental animals to infection

by *T. congolense* and their complete resistance to the *T. vivax* group make the use of goats and sheep essential, and these animals are often difficult to obtain and to protect from accidental infections in tsetse areas. In every area examined a specially constructed camp is an essential, and as Bruce states, the factor of infectivity obtained is an absolute minimum.

TABLE I.
Ratio of Infective *G. morsitans* per 1,000 Flies recorded in Nyasaland and Northern Rhodesia, obtained by Fly-feeding Experiments.

Species.	Nyasaland. Roy. Soc. Comm. 1912 10,681 flies examined.	Rhodesia, Luangwa Valley. K. & Y. 1911-12. 3,410 flies examined.	Rhodesia, Tanganyika Plateau. K. & Y. 1912. 5,250 flies examined.
<i>T. brucei</i> vel <i>rhodesiense</i> ...	2.0	1.9	0.7
<i>T. simiae</i> (ignotum, K. & Y.)	3.4	3.3	3.2
<i>T. congolense</i> (pecorum) ...	4.6*	0.6**	0.2***
<i>T. caprae</i> (vivax) ...	3.5*	—**	—***

* Goats employed. ** Monkeys only. *** 2 goats only in 42 experiments.

For statistical purposes, provided that the infectivity of the flies is not exceedingly low, dissection of the flies and identification of the infections by microscopic examination seems to us to be a much more accurate method, and it is clearly more mobile. The only comprehensive figures obtained by this means, where several species of trypanosomes are concerned, appear to be those given by the Royal Society's Commission in Nyasaland (3), who in 1913 dissected 1,060 *G. morsitans* and identified in them *T. brucei* vel *rhodesiense* once, *T. congolense* 6 times, *T. simiae* 12 times, and *T. caprae* 14 times; but it is not stated in their report what proportion of these infections were mature.

Large numbers of *G. morsitans* and *G. palpalis* have been dissected by Duke (14) but he does not record more detail than the site of the infections in the fly. He gives the following figures for 2,206 "*G. morsitans*" in the Mwanza fly area of Tanganyika Territory, where a severe sleeping sickness epidemic was in progress:—containing flagellates, 9.3 per cent.; proboscis + gut infections, 1.9 per cent.; proboscis only, 6.5 per cent.; gut only, 0.7 per cent.; gut and gland, 0.13 per cent. For 1,500 *G. palpalis* similarly examined on Damba Island the infections recorded are:—containing flagellates, 1.3 per cent.; proboscis only, 1.1 per cent.; gut only, 0.19 per cent.

Between September 1921 and April 1922 in the course of a tsetse-fly survey in Northern Nigeria we dissected and examined some 2,500 flies comprising 448 *G. morsitans*, 1,497 *G. tachinoides* and 534 *G. palpalis*. The dissections were carried out in rest-houses improvised as laboratories, and while travelling by steam-launch or poling barge. The flies were fully examined and all organs containing flagellates were permanently mounted. The preparations were submitted at first to a very cursory examination, the results of which have been recorded elsewhere (4). The findings made by the more exhaustive subsequent examination are given below. The slowness of this method is its chief drawback. With one worker dissecting and the other examining the organs it was difficult to deal with more than forty flies in the day, even if no travelling was done, while on days when we trekked, only about half that number could be dealt with. At this rate figures total up slowly, and a prolonged stay in a locality is necessary to obtain any idea of the infectivity of the flies there, while for comparative purposes various localities have to be grouped together. At the same time the first attempt at a more rapid method of examination was made by collecting from each fly before dissection the small drop of salivary exudate which can be expressed from the tip of the proboscis by slightly squeezing the insect. The numbers of

mature infections (i.e. those in which the infective form of the trypanosome was actually demonstrated) of the *T. vivax* and *T. congolense* groups discovered by dissection were:—in *G. morsitans*, 44; in *G. tachinoides*, 33; and in *G. palpalis*, 9. The numbers which would have been discovered if the salivary exudate only had been examined were:—*G. morsitans*, 22; *G. tachinoides*, 10; and *G. palpalis*, 9. Moreover the salivary exudate is very impervious even to prolonged staining (3 per cent. Giemsa for 12 hours), the trypanosomes often appearing as faintly detailed ghosts in a heavily stained matrix and being then difficult to identify. This difficulty can be avoided by receiving the exudate into a tiny drop of serum, when excellent fixation and staining is obtained, but the fact that only a proportion of the infections is discovered makes this very rapid method of examination useless for statistical purposes and it has been abandoned. More recently we have observed under the microscope salivary secretion exude in some quantity from the hypopharynx and leave the infective trypanosomes in situ.

Since all infections of the *vivax* group and all mature infections of the *congolense* group of trypanosomes are discoverable by careful dissection of the proboscis alone a series in which this organ only was examined was next carried out. The proboscides of 3,458 *G. tachinoides* and 623 *morsitans* were thus examined in the last eight months of 1922, a few hours each week being devoted to the work. The objection to this method is that it does not certainly reveal the mature infections of the *brucei* group, though some are found by it.

Writing of the development of *T. gambiense* in *G. palpalis* Miss Robertson (5) says "The [salivary] gland [of the tsetse-fly], as is well known, is composed of (1) a narrow tubular part, which leads back to (2) a slightly broader cellular part, which in turn leads to (3) the glandular part where the full width of the organ is attained. The trypanosomes settle down and attach themselves in the second part of the gland or at the entrance to the third part, the rest of the gland being quite free from trypanosomes." Later, of course, the whole gland is involved.

Therefore, in order to detect mature infections of the *brucei* group, a method of dissection has been developed which yields the first two parts of the salivary glands, which are cut across at the entrance to the third part, attached to a completely dissected proboscis. This was designed to discover all the mature infections of the *brucei* group and theoretically it should do so. The rarity with which we have encountered them, however, makes us hesitate to say that none is missed. Of the seven mature infections of the group, viz. two *T. gambiense* and five *T. brucei*, which we have obtained in laboratory-infected *G. tachinoides* it was our opinion that five could not have been missed by our rapid method of dissection, but in the case of the other two the flagellates could not be detected in the fresh preparations of the whole gland, though their presence was suspected as the proventriculus was infected and loose forms occurred in the labial cavity. In both these cases the invasion of the salivary glands was proved by subsequent examination of the stained films. Two mature infections of the group have been found by the rapid method of dissection in wild *G. tachinoides* at Sherifuri. In each case the active trypanosomes were very obvious in the clear anterior parts of the glands. On the other hand at the same place two dogs were infected with *T. brucei* by feeding 260 and 210 *G. morsitans* respectively, while a third fed 630 *G. morsitans* and did not contract the disease. In these 1,100 flies there were thus at least two *brucei*-infective ones, but by the rapid method of examination 4,500 *G. morsitans* have been dealt with in the same area and no mature infection of the group has been discovered in them. These facts make us uncertain at present that this rapid method has the practical value which in theory it should have. The question is being considered in further experimental work.

The flies can be dealt with at an average rate of fifty or more an hour. All mature infections of the *T. vivax* and *T. congolense* groups and most infections of the *T. brucei-gambiense* group are discovered. For reasons which will appear, the phrase "mature infection" is preferred to "infective fly."

II. TECHNIQUE.

1. *The Full Dissection.*

The "salivary drop," as the exudate from the proboscis was named, was obtained by exerting light pressure on the living fly with the finger and thumb from behind forwards so that the soft skin at the base of the proboscis became distended. A needle was then placed on the front of the head and a minute drop of fluid appeared at the tip of the proboscis. This was received on a slide with a smearing motion. Eight or ten were taken in series on the same slide and were ringed and numbered. All were subsequently examined regardless of whether trypanosomes were discovered in the dissection. The fly was then transfixed on a needle and dissected under the low power of a dissecting microscope. The salivary glands were extracted through the thorax by the method described by one of us (6); the proventriculus and gut were next examined and finally the proboscis, which was roughly opened. It is not possible to dissect the last named organ under the low power, and it is thus largely a matter of chance whether the hypopharynx can be seen or not, while the opacity of the bulb conceals some of the lighter infections. Any organ in which flagellates were detected was teased up in a fresh drop of saline, spread out, rapidly dried, fixed with absolute alcohol and stained with 2-3 per cent. Giemsa stain for twelve hours. At first normal saline was used, but the strength was later dropped to 7 per cent. NaCl, and it was discovered subsequently, though not in time to be of use in this series of dissections, that if the infected organs are teased up in freshly collected fowl serum much better results are obtained, with the exception mentioned below. In this medium the flagellates may be fixed and stained with almost the same differential uniformity as in thin blood smears.

2. *Proboscis Dissection.*

The fly was killed by pinching the thorax and the head was twisted off. The proboscis was dissected while still attached to the head but by a method so closely similar to that next described that it needs no separate description. Only those in which the infective form of trypanosome was actually seen in the hypopharynx were mounted. These final stages are easily distinguished from the developmental forms of trypanosomes in the fresh preparation. The infected proboscis was teased up in a small drop of fresh fowl or carbolated horse serum, either of which gives good results, except in the intensely dry months of the harmattan, when the films crack and curl on the slides. Under these conditions saline must be used. It may be mentioned here that methods of wet fixation are not suited to proboscis preparations as the material floats from the slide.

3. *Proboscis and Salivary Gland Dissection.*

In these dissections much use was made of simple native assistance. One native released the flies singly from the collecting boxes into a net, caught them and killed them by pinching the thorax and handed them to a second who cut off the abdomen and wings of the fly with scissors and placed the head and thorax in a large drop of saline on a slide. These he handed to the dissector with whom he kept time. A third native kept up a supply of slides and cover-slips. This utilisation of native assistance greatly increases the speed of the work and prevents distraction.

The needles used are tolerably fine ones, but neither requires a cutting edge, as only one simple cut is made. Short needles can be used with more precision than long ones. The dissection is done at a magnification of 30 diameters, and as some transmitted light is imperative, a dark ground condenser was used with a blue glass inserted to give a monochromatic light and reduce eye-strain. The method of dissection is shown in a series of diagrammatic sketches.

Text-figures i-vi. Illustrating a rapid method of dissection of proboscis and salivary glands of *Glossina* :

1, right needle ; 2, left needle ; 3, base of wing ; 4, cut abdomen ; 5, salivary gland ; 6, turgid skin ; 7, palpi ; 8, mass of muscle ; 9, labrum ; 10, hypopharynx ; 11, last position of right needle ; 12, point for extraction of broken salivary glands ; 13, sphincter muscle on salivary duct.

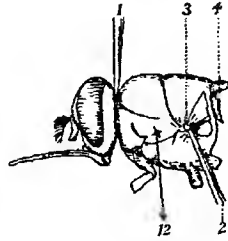


Figure i.

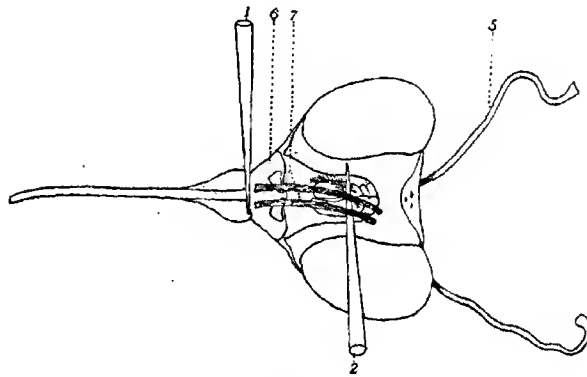


Figure ii.

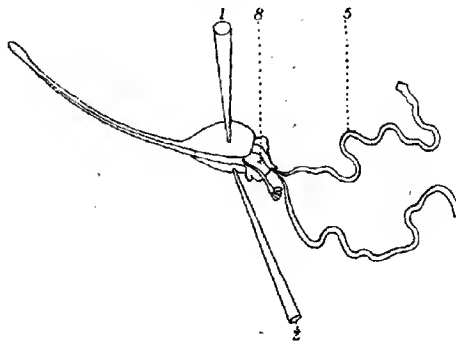


Figure iii.

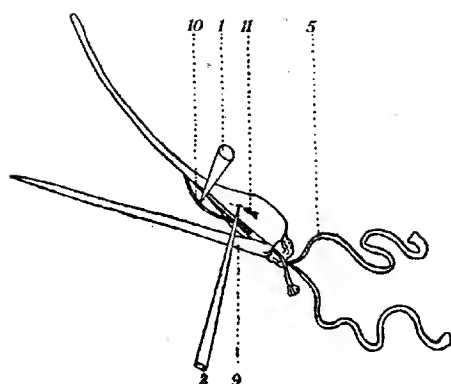


Figure iv.

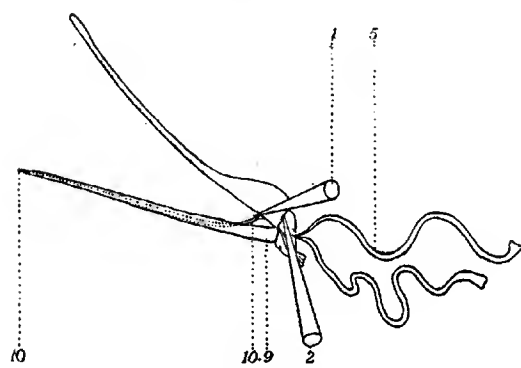


Figure v.

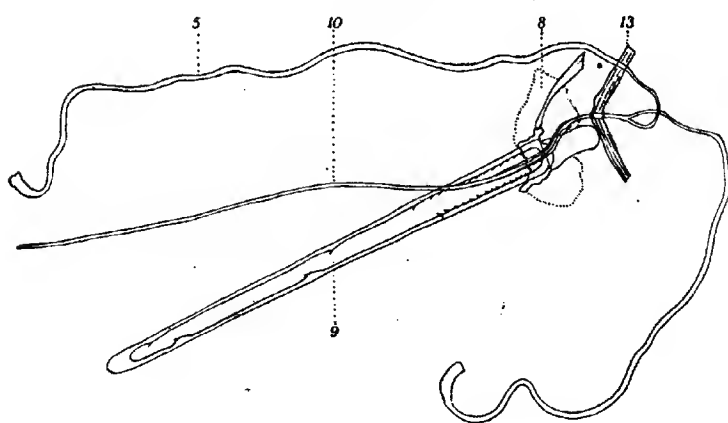


Figure vi.

Fig. i shows the left needle piercing the thorax at the base of the wing, which is the strongest point. The right needle is placed across the neck and this twists the head round till the proboscis lies on the slide and the neck is immersed. The left needle holds the fly firmly while the right one is worked to and fro and at the same time pushes off the head with a steady movement. Directly the cuticle of the neck breaks, pressure on the thorax ceases, and it is better to raise it ever so slightly from the slide, but not enough to lift from the fluid the salivary ducts, which can now be seen. The head is then lightly pushed forward and draws with it the thoracic part of the salivary glands. The thorax is removed from the slide.

Fig. ii. The head is placed with the face upwards and the left needle is laid on it with sufficient pressure to throw the proboscis forward and the palpi up and back. The turgid condition produced is shown in the figure. The right needle is laid rather horizontally across the base of the proboscis, and this is separated from the head by the same sawing pull which was used before, and again directly separation occurs pressure must be taken off the hinder part or the salivaries will be pulled off. The right needle must be kept in position while the left one draws the head back and leaves the preparation as seen in the next figure. The head is left on the slide until the end of the dissection as it is important that the proboscis should not be allowed to get free since it is most difficult to recapture.

Fig. iii. The left needle has been thrust into the left side of the bulb and the right one has been lifted so that the proboscis rolls almost on its side. The right needle is next pushed into the bulb as shown and at such an angle as to compress it slightly from side to side.

Fig. iv. The left needle has released the gutter-shaped labrum from the labium, and very occasionally the hypopharynx will come with it. The right needle has maintained its position (No. 11 in the figure) until the left one is free to be placed slightly in front of it and a lateral compression is exerted on the bulb. The hypopharynx passes into the labial cavity through the dorsal flat face of the bulb as shown and fits closely into a somewhat deep groove of the labium. At this stage of the dissection it can just be seen bulged out by the pressure of the left needle. The right needle is placed behind it and gently pushes it free, moving distally as it does so. The hypopharynx now usually springs across and lies in the gutter of the labrum.

Fig. v. The right needle has momentarily rested on the bulb again while the left one is freed and the latter is now placed obliquely on the lower edge of the inside of the bulb. The right one is placed between the elements just anterior to the point where the hypopharynx emerges. It is then drawn sharply backwards so as to cut off against the left needle practically the whole of the bulb. Further clearing of the preparation is rarely needed, as the two small flaps of bulb which remain float outwards. They can easily be removed if necessary and any excess of muscle can be similarly dealt with, but most of it comes away with the single cut. The head is now removed from the slide and the preparation covered and examined.

Fig. vi shows the appearance of the mounted preparation.

The remedies for accidents which sometimes occur may be given. Firstly, the salivaries occasionally break at the duct, apparently owing to the ends being trapped between the cut flaps of the abdomen. If the breaking strain is seen when the pull begins, the right needle should be freed from the head and pushed up and down against the cut abdomen in order to wet it, as this often eases the tension and allows the glands to come away. If they do break, the right needle should be thrust through the thorax at the point no. 12 in fig. i and ripped downwards, as this cut will often bring out the glands quite cleanly and, at any rate, draws out the ends, which may be trapped by a horizontal needle and withdrawn. Secondly, the hypopharynx may be cut in the first attempt to release it from its groove. It may be recovered by gently stroking the labium with a horizontal needle from the bulb forwards, when it comes out from the

tip of this organ. Finally, the last cut may break the hypopharynx free, and, as it floats up and is liable to get into an air bubble or to the edge of the cover-slip, it has become our practice to lift the labrum with the salivaries and put them on the top of it so that it is anchored in position.

The labium need not be examined, as trypanosomes are never found in it if the labrum is negative. The most usual site of light infections is at the extreme base of the latter organ. The whole of the labrum is very clear and the lightest infection is not missed. Small colonies of six or fewer trypanosomes are often detected, and occasionally a single fixed individual is seen. These are missed unless the bulb is cut away completely, and even after the hypopharynx has been invaded it is not always possible to detect the colonies of developmental forms in the extreme base unless this is well cleared. Heavy infections are often detected under the dissecting microscope as the colonies are somewhat opaque and give the labrum a smoky appearance, local or diffuse.* If the infective forms are detected in the hypopharynx or salivary glands a large drop of saline is placed on the edge of the cover-slip in order to flood the preparation when the cover is raised. The preparation is then transferred to a small drop of saline or serum. The size of the drop varies with the season, being very small on moist days and larger under dry conditions, but in any case it should not be so large as to allow the labrum to float, as this makes proper teasing impossible. A pair of specially fine needles are kept for this purpose only, and the cutting begins at the distal end of the labrum as the heavier end anchors the preparation. Both labrum and hypopharynx may be cut across together some eight or ten times, a free hypopharynx being difficult to sever. The drop is then spread a little to ensure immediate drying.

III.—IDENTIFICATION OF INFECTIONS.

The trypanosomes encountered were referred to their groups by a combined study of the developmental and infective forms, both of which in most stages are group-specifically distinct, while their position in the fly is an additional aid. The identifications are based partly on the work of previous investigators, especially that of the various Royal Society's Commissions, and partly on our own observations in laboratory-infected *G. tachinoides*. A familiarity with the forms was acquired in the examination of many hundreds of infections encountered in the dissections. At present it is not possible to make a more exact identification than that into groups. Bruce and his co-workers, however, could distinguish *T. simiae* from *T. congolense* (*pecorum*) in the fly by the larger size of the former (3). Authorities differ widely as to the number of tsetse-borne trypanosomes, but all are now agreed that there is a great deal of synonymy in the nomenclature, owing to the occurrence of strains of such markedly varying virulence in different localities, and differentiation based on minor details of morphology, especially dimensions. Ultimately group identification may prove to be as far removed from specific identification.

Four species of pathogenic tsetse-borne trypanosomes are known to occur in Nigeria, viz.—*T. gambiense*, Dutton (*nigeriense*, Macfie), *T. brucei*, Plimmer & Bradford (*pecaudi*, Laveran), *T. congolense*, Broden (*pecorum*, Bruce, *dimorphon*, Laveran & Mesnil) and *T. vivax*, Ziemann. The last three were recovered from *G. tachinoides* in

* A diffuse smoky appearance is not always due to trypanosome infection. Sometimes the labial cavity is full of amorphous debris or blood cells. This is especially the case with bred flies which have lived some time in captivity. In these cases the hypopharynx may be enveloped in a mass of agglutinated red cells, and once a fungous growth was found on this which filled and grew out from the labial cavity. Often, too, the elements of the proboscides of bred flies are stuck together as though with dried blood. In several species of tsetse the habit of settling on damp sand and inserting the proboscis has been noted, but as no observer has been able to prove that they drink water the habit has been unexplained. It seems likely that the flies behave in this way simply to clean the dried blood from the proboscis.

Southern Nigeria by Macfie (7), and have also been obtained by us from the same fly in both Sokoto and Kano provinces by feeding the flies when freshly caught on experimental animals. All four of the species have been transmitted by us in the laboratory. *T. simiae*, Bruce, is not known to occur in West Africa, nor has *T. rhodesiense*, Stephens & Fantham, been recorded there. The non-pathogenic *T. grayi*, Novy, is widely distributed in *G. tachinoides* and *palpalis*. The characters on which the identifications are based are as follows:—

Trypanosoma vivax Group.

The development is confined to the *proboscis*. Trypanosomes have been seen in the gut and crop up to the fourth day after the infecting meal, but they appeared to be degenerating from the first, being elongated and having the macronucleus diffuse. They could not be confused with the species which develop in the gut (Pl. xxiv, figs. 13, 14). The developmental forms in the labial cavity are all free-flagellated crithidia in compact fixed colonies, short and boat-shaped when the colony is small, but very elongated and scroll-like in large colonies (Pl. xxv, figs. 1, 2). They are seldom truncated at the posterior end, a characteristic of the analogous forms in the *T. congolense* group. The intermediate forms between these and the infective forms, that is the "preinfectives," are crithidia with the kinetonucleus and macronucleus in close contact at the aflagellar end, free-flagellated and somewhat undulant (Pl. xxv, figs. 3, 4). These invade the hypopharynx and after an anterior movement of the nucleus become the infective forms, which are slender, markedly undulant, free-flagellated organisms with a sharply pointed aflagellar end (Pl. xxiii, figs. 5-11).

Dr. W. Yorke has pointed out that they have also that Indian-club shape which is characteristic of the *T. vivax* group in the blood. Except for size they closely resemble the blood-forms. The dimensions of the infective forms were found to be as follows:—

Fly.	No. measured.	Average length.	Average length of free flagellum.	Average breadth at nucleus.
<i>G. tachinoides</i> ...	75 in 23 flies	14.4 μ (10.3-18.8)	3.9 μ (1.2-7.8)	1.8 μ (1.0-2.9)
<i>G. palpalis</i> ...	25 in 2 flies	14.9 μ (11.6-19.1)	4.3 μ (2.4-6.5)	1.9 μ (1.2-2.8)
<i>G. morsitans</i> ...	50 in 10 flies	14.8 μ (11.3-18.5)	4.1 μ (2.5-7.0)	1.6 μ (1.0-2.5)

The free part of the flagellum is thus on the average between one-third and one-fourth the whole length of the organism. They have not been seen to divide in the fly and are the only trypanosomal forms in the development in the fly—a convenient distinction from *T. congolense* in the proboscis as in this case trypanosomal forms are always present. A curled up form is shown in Pl. xxiii, fig. 9. These are not uncommon in the heavier infections and are especially frequent in the salivary exudate which the fly will eject on a slide. We are inclined to regard these as resting infective forms. The infective forms of *T. vivax* are not produced in the same profusion as the analogous forms of *T. congolense*; and often a very light invasion of the hypopharynx is seen, only some six to ten organisms being present.

Reference to the work of Fraser & Duke (15) on the development of *T. uniforme*, Bruce, in *G. palpalis* and of Bruce (3) on that of *T. caprae*, Kleine, will show how closely the forms of these species resemble those of *T. vivax*. It is very probable that *T. caprae* and *T. vivax* are specifically identical.

Trypanosoma congolense Group.

The site of early development is the mid-gut, where only trypanosomal forms occur. The shorter forms are aflagellate, or almost so, and feebly undulant (Pl. xxiv, figs. 5-8). A form much like the blood-form is often present, while the very short form figured suggests that the infective forms may be swallowed by the fly as these are not infrequent in the gut. A longer free-flagellated

form is produced which moves forward to the proventriculus and thence to the labial cavity (Pl. xxiv, fig. 9). No character which will serve to distinguish this proventricular form from the analogous form in the *brucei-gambiense* group has been found. In the labial cavity the organisms become aflagellate, or almost aflagellate, crithidia which are in uncompact colonies. In fresh specimens the looseness of the organisms is characteristic as compared with *T. vivax*. The individual crithidia are very frequently abruptly truncated at the posterior end (Pl. xxv, figs. 5, 6). The only form in the proboscis which can be confused with *T. vivax* is shown in Pl. xxv, figs. 7, 8, and is very slender and free-flagellated with the kinetonucleus in close contact with the macronucleus at the aflagellar end of the organism. It seems probable that this is the preinfective form, as it has been seen to invade the hypopharynx in laboratory-infected flies (Pl. xxv, fig. 8).

The infective forms are produced in great profusion, light infections of the hypopharynx being rarely encountered. If they divide in the fly such multiplication is rare, but an appearance which strongly suggested division was once seen. They are small stumpy aflagellate organisms with a blunt posterior end, feebly undulant and closely resembling the shorter forms of *T. congolense* as seen in the blood.

The dimensions of the infective forms were found to be as follows:—

Fly.	No. measured.	Average length.	Average breadth at macronucleus.
<i>G. tachinoides</i>	50 in 5 flies	11.1 μ (8.9-13.0)	1.6 μ (0.9-2.4)
<i>G. palpalis</i>	25 in 1 fly	11.1 μ (9.2-13.6)	1.7 μ (1.3-2.2)
<i>G. morsitans</i>	75 in 16 flies	11.2 μ (9.0-13.0)	1.6 μ (1.2-2.5)

T. simiae (*T. ignotum*, Kinghorn & Yorke) is the only other well-defined member of this group, and its development according to the account of Bruce (1) is closely similar to that of *T. congolense* except that throughout the forms are somewhat larger in *T. simiae*.

Trypanosoma brucei-gambiense Group.

The fullest account of the development of a tsetse-borne trypanosome in the fly is that given by Miss Robertson of *T. gambiense* in *G. palpalis* (5). The first phase of development is in the mid-gut. The infection in this site may be distinguished from the *T. congolense* group by the fact that while the organisms of these species are aflagellate or almost aflagellate *T. brucei* and *gambiense* are almost always free-flagellated. There is, however, some variation in the length of the free flagellum in different cases. Of the large number of forms figured by Miss Robertson only one of the typical trypanosome form is shown as aflagellate, and in a case of *T. brucei* in *G. tachinoides* we noted three aflagellate forms in 200 counted. This is the typical picture, but in one case of ours of *T. gambiense* in *G. tachinoides* the free part of the flagellum is reduced to the condition which has been called a "spike" in many of the forms. Trypanosomes like those figured in Pl. xxiv, figs. 1-3, are, however, always to be found in numbers and *T. congolense* has no forms like them. According to Miss Robertson and in our own experience there are no true crithidia in the gut. Kleine and Taute (12) figure a number of slender crithidial forms which they call "males," as opposed to the broad trypanosomes which they call "females." Miss Robertson points out that there is neither evidence nor analogy in favour of this distinction, and after stating that these slender "crithidia" are of rare occurrence she gives reasons for considering them to be merely degenerating slender forms. In any case they are quite distinct from the broad well-defined crithidia of *T. grayi* and also from the long thread crithidia which sometimes abound in this species. Therefore even if a preparation is encountered where they occur in numbers there should be no difficulty in diagnosis.

The completion of the gut development occurs when the proventriculus is invaded by long slender free-flagellated forms (Pl. xxiv, fig. 4), and we have seen no character which will serve to distinguish the proventricular type of *T. brucei* and *T. gambiense* from *T. congolense* in the same site. These slender forms invade the salivary glands by way of the labial cavity and hypopharynx and the next stage is marked by the appearance in the glands of short, broad, free-flagellated crithidia (Pl. xxv, figs. 9-12). It is doubtful whether they could be distinguished from the short broad crithidia of *T. vivax* except by their position in the fly. The infective forms (Pl. xxiii, figs. 1-4) have a blunt posterior end and are of a more uniform width than those of *T. vivax*. The free part of the flagellum is shorter, averaging only about one-eighth of the organism as opposed to one-third to one-quarter of *T. vivax*. Transitional forms between crithidium and infective, in which the nucleus and kinetonucleus are opposed at the posterior end of the organism, occur, and coiled-up forms are common. The infective forms in this group divide in the fly. The dimensions of the infective forms of *T. gambiense* and *T. brucei* in *G. tachinoides*, fifty being measured in each case, were:—

	Average length.	Average length of free flagellum.	Average breadth at nucleus.
<i>T. gambiense</i>	14.6 μ (12.1-17.3)	1.7 μ (0.5-2.8)	1.5 μ (1.0-2.5)
<i>T. brucei</i>	15.8 μ (13.3-18.0)	2.1 μ (1.1-3.5)	2.2 μ (1.4-3.0)

Roubaud and Bouet, in an account of the development of *T. pecaudi* (probably = *T. brucei*) in *G. tachinoides*, *longipalpis* and *morsitans*, state that when the infection is mature the labial cavity is involved in the infection, that is, as in the *T. congolense* group (8). This was early work and has not been confirmed. Duke points out that there is no reference to the salivary glands in their account (9). It appears to us that there has been too much insistence on the absence of flagellates from the proboscis in mature infections in this group. The Luangwa Valley Commission record an instance in which the proboscis of a bred *G. morsitans* was heavily infected with *T. rhodesiense*, the salivary glands of course being also involved, and in our experience with *G. tachinoides* in the seven mature infections of this group, viz., two *T. gambiense* and five *T. brucei*, there have been trypanosomes of the proventricular type in the proboscis in every case. Nor is this surprising, since the invasion of the salivary glands is by way of the hypopharynx and this can only be reached through the labial cavity. The proboscis fulfils the rôle of a highway between two towns. It seems likely that if the bulb of the proboscis is removed in the manner we describe the trypanosomes will be detected there in most if not in all cases. Roubaud and Bouet's observation would thus be incomplete rather than incorrect.

Trypanosoma grayi.

This species is only recorded from the gut of the fly. It is at once distinguished from the foregoing by the invariable presence of broad crithidial forms. Minchin (10) gives the following characteristics:—Large macronucleus, oval or compressed, situated not far from the posterior end of the organism; large, usually rod-shaped, kinetonucleus; kinetonucleus either anterior or posterior. The same author records cyst-like bodies from the proctodaeum. The infection was encountered by us in 70 flies and in all cases but one the flagellates were confined to the mid-gut and generally the hind part of this. In the exception, a *G. tachinoides*, the flagellates were also seen in the proventriculus but were of the normal mid-gut type. The flagellate appears to have no anterior station in the fly. In the lighter infections all the flagellates are of a stout crithidial type with a long free flagellum (Pl. xxiv, fig. 10). In some infections, together with these forms, are large numbers of long thread-like crithidia of the type figured in Pl. xxiv, fig. 11, reaching the great length of 60-70 μ . In massive infections trypanosomal forms are found and may predominate to such an extent that

the crithidia have to be searched for. They are, however, always present together with transitional forms in which the kintonucleus lies over the macronucleus, the free part of the flagellum shortening as the kintonucleus passes backwards. The trypanosome itself is almost aflagellate (Pl. xxiv, figs. 12, 13).

Trypanosoma gallinarum.

This species of avian trypanosome is known to have a capacity for multiplying in the mid-gut of *G. palpalis*, but the tsetse is not considered to be even a facultative host (5). It has not been recorded from wild flies, but as it may occasionally occur in these its distinctive characters may be given. Miss Robertson's description and figures show that all the forms are crithidial—a ready distinction from the gut forms of the pathogenic trypanosomes. The crithidia have the free part of the flagellum long and of all other flagellates known to occur in tsetse they most nearly resemble the short boat-shaped crithidia found in the proboscis of a *vivax*-infected fly, such as is figured in Pl. xxv, fig. 1. The kintonucleus "presents the somewhat curious double appearance of two closely-opposed granules lying one behind the other." This feature is sufficient to distinguish *T. gallinarum* from *T. grayi*, in which the kintonucleus is single and often rod-shaped.

Double Infections.

Double infections of tsetse with *T. vivax* and *T. congolense* are not uncommon, usually only one species being mature. In several instances however in *G. morsitans* and *G. tachinoides* the infective as well as the developmental forms of both trypanosomes have been found in the same fly.

IV. A COMPARISON OF THE INFECTIVITY OF THE PREVALENT TSETSE OF N. NIGERIA.

An analysis of the infections discovered by full dissection of the flies is given in Table II. *T. grayi* is dealt with separately in the next section. These flies were collected over a wide area extending from Numan on the Benue R. in the east to Kwiambana in South Sokoto Province in the west, and from Baro on the Niger R. in the south to the latitude of Kano in the north. The table gives a rough comparison of the disease-carrying properties of the three prevalent species of tsetse for the country generally, except as regards the *brucei-gambiense* group, of which so few infections were encountered. It will be seen that *T. vivax* and *T. congolense* have been found in all three, the former being the more common in all, about one-fifth of the total infections being referable to the latter group in *G. tachinoides* and *G. palpalis*, and about one-third in *G. morsitans*. This may be due to differences in feeding habits or to variation in the capacity of the various trypanosomes to develop in the different flies.

TABLE II.
The Trypanosome Infections found by Complete Dissection of Tsetse-flies in various Localities in N. Nigeria. All in Percentages.

Fly.		<i>G. morsitans</i> .	<i>G. tachinoides</i> .		<i>G. palpalis</i> .
			Wild ungulata common.	Wild ungulata very scarce.	
Number examined	...	448	1,093	404	534
<i>T. vivax</i> Group	Mature	6.5	2.0	0.7	1.5
	Immature	12.3	5.6	1.0	1.1
	Total	18.8	7.6	1.7	2.6
<i>T. congolense</i> Group	Mature	3.1	0.6	0.5	0.2
	Immature	5.1	1.3	0	0.4
	Total	8.2	1.9	0.5	0.6
<i>T. brucei-gambiense</i> Group	Mature	0	0	0	0
	Immature	0.4	0.2	0	0
	Total	0.4	0.2	0	0

The *G. tachinoides* are divided in the table into two classes according as to whether the wild ungulata in the spots where they were collected were more or less numerous or very scarce. There are many areas in Northern Nigeria, mainly in the drier northern parts, in which the larger wild fauna has been practically exterminated. In these there is little evidence of the existence of the smaller antelopes or wild pig and the larger antelopes have entirely gone. Monkeys and sometimes baboons remain plentiful, and from this one may judge that there is a considerable fauna of small mammals. Where there is suitable water *Varanus* always persists and in some cases crocodiles also. The birds are not greatly affected, except where farms have entirely replaced the forests. Cattle, horses, asses, sheep and goats generally abound in them. These areas are for the most part outside the range of *G. palpalis*, or at any rate it is somewhat difficult to judge what number of the smaller antelope, such as bushbuck, lurk in the heavy forest mainly frequented by this tsetse. Instances have been met with, however, in which colonies of this fly persist under such conditions of a reduced wild fauna. *G. morsitans* has not been encountered by us in any area where there were no signs of large antelope. *G. tachinoides* on the other hand is widespread, and sometimes numerous in these areas, and in some cases contact with wild ungulates is a practical impossibility. A comparison could therefore be made in this species of the trypanosome infections in flies from areas where game was scanty or almost absent with those from places where it was more numerous. In areas where game was present in some quantity, 1,093 *G. tachinoides* were dissected, and pathogenic trypanosomes were found in 105 (9.6 per cent), while where game was virtually absent the 404 flies examined gave only 9 infections (2.2 per cent.). In *G. palpalis* pathogenic trypanosomes were found in 17 of 534 flies (3.2 per cent.) and in *G. morsitans* in 123 of 448 flies (27.4 per cent.). These figures correspond with the cattle-inhibiting influence of the various flies under existing conditions. Thus *G. morsitans* was present, alone or with one or both of the other species, in 47 localities, and in 43 of these there were no cattle. *G. tachinoides* was present as the sole species of tsetse in 32 localities, 17 of which had no cattle. *G. palpalis* was present as the sole species in 36 localities, and 17 of these had no cattle. These observations confirm and extend Macfie's findings in Ilorin Province (11).

It was never possible to compare the three prevalent species of tsetse in any considerable numbers from the same locality, but such strict comparisons between *G. morsitans* and *tachinoides* could several times be made, as these two flies often occur together, the former ranging out more from the thickets and heavier forest (kurumi) than the latter. The comparisons were made at the following spots:—

(1). Sherifuri on the Katagum River, N. of Azare, a wide sandy stream with banks heavily forested and backed by dry thorn bush with extensive shady pools. There is much small game, especially wart-hog, and scanty large game, including buffalo. An important trade route crosses at this point, and the country, outside a zone of some four miles on both banks of the river, is well populated but without cattle. The total infections found were:—

<i>G. morsitans</i>	12 in 48 = 25 per cent.
<i>G. tachinoides</i>	5 in 42 = 12 per cent.

(2). Shellim, 30 miles east of the above and on the Messau River, a large stream with mud banks and rather scanty shade, backed by savannah type forest and old farmed land. Not much sign of game, but waterbuck were seen, and good game country, thinly populated, lies to the north-east. The locality abuts on an important cattle area to the west and a large cattle road skirts it. No other *morsitans* area we saw held so little game, and nowhere else was so light an infection encountered in this species. The infections were:—

<i>G. morsitans</i>	7 in 80 = 9 per cent.
<i>G. tachinoides</i>	1 in 11 = 9 per cent.

(3). Jagale, a small stream, some 12 miles west of the Gongola River and 40 miles north of the R. Benue; in pools at our visit, heavily shaded and with extensive

kurumi in the neighbourhood. Large antelope plentiful. The nearest settlement was four miles distant, but there was a story of an attempted settlement here which failed on account of sickness. The infections discovered were :—

G. morsitans 12 in 50 = 25 per cent.

G. tachinoides 4 in 35 = 11·7 per cent.

(4). Dau, a small stream, in pools at our visit, flowing into the Gongola River from the west and some 25 miles north of the last named locality. Dau is near the source of the stream which lies in a narrow valley with steep laterite cliffs. The floor of the valley has heavy primary forest. The land above is fairly extensively farmed, but the farms are occupied only during the rains and harvest season. The kurumi is avoided by the local natives, who say the water is poisoned. Large antelopes are plentiful, giraffe and buffalo also occur. It is surrounded by important cattle ground on all sides, but the animals are not brought to the spot and so lose the only good grazing during much of the dry season and are laboriously watered from deep wells. The infections found were :—

G. morsitans 15 in 71 = 21 per cent.

G. tachinoides 7 in 81 = 8 per cent.

(5). Mashiwashi, in S. Sokoto Province near Kwiambana; the site of our wet season camp in 1922. The stream was a small one with sandy bed, and water was in holes only during the dry season. It was bordered by a heavy dense kurumi of rain forest type with open glades. The part of the kurumi with which we were concerned was some 200 yards wide and a mile long, grading off into a thin deciduous forest on the higher ground. A small village was cut out of the dense forest, but this was normally uninhabited during the farming seasons, the people working on outlying clearings. The country is thinly inhabited and there are no domestic animals except a few dogs. There is little animal transport on the main road except for a few donkeys which bring salt from Zaria. Hartebeeste, roan antelope, bushbuck and wart-hog are tolerably plentiful, while the red-flanked and common duikers occur in numbers. There are no baboons, crocodiles or, so far as we could determine, *Varanus*. There was a large troop of monkeys. *G. palpalis* was present in small numbers; *G. morsitans* was not very numerous, the spot being near the edge of its range here; *G. tachinoides* abounded, some 26,000 being caught in the small area during our six months' stay. Full dissections of the last two species were carried out in May and June, and the infections discovered were :—

G. morsitans 71 in 176 = 40 per cent.

G. tachinoides 60 in 416 = 14 per cent.

The last figure is probably artificially lowered to some extent as explained below (p. 281).

Taken individually the numbers are small, but with the exception of Shellim, where one infection in the few *tachinoides* examined occurred, the localities all give the same result, namely, that where the two species are found together the infection in *morsitans* is double or more than double the infection in *tachinoides*. That this is at least not entirely due to any capacity of the trypanosomes for establishing themselves more readily in *G. morsitans* is shown by examination of the gut contents. When the recognisable blood was distinctly referable to the type which has a very small red cell, such as is found in most antelope and cattle, a note was kept. In these five localities in *G. tachinoides* mammalian blood was recognised in 63 flies, and 13 per cent. of it was of the small-celled type. In *G. morsitans* it was recognised in 80 flies, and 56 per cent. was of the small-celled type. Allowing a margin for experimental error, the difference is still great, and, apart from this, other evidence was obtained that though *G. tachinoides* does attack the Ungulata freely it has no special predilection for them, and in an undisturbed area takes a considerable proportion of its food from those animals, such as baboons, which have not been incriminated as reservoirs of the pathogenic trypanosomes.

V.—TRYPANOSOMA GRAYI IN *G. PALPALIS* AND *G. TACHINOIDES*.

This parasite was met with frequently in the mid-guts of *G. tachinoides* and *palpalis*, but never in *morsitans*. It seems almost certain that it is a blood parasite of one of the common hosts of riverine tsetse, and it is hard to dissociate it from a non-mammalian source. Kleine (12) has shown that flagellates resembling *T. grayi* develop in *G. palpalis* after the flies have fed on crocodiles, and this animal is known to harbour the trypanosome *T. kochi*.

The non-mammalian blood encountered by us in *G. palpalis* and *tachinoides* conformed to one type and was considered to be reptilian. Haemogregarines were frequently found in it. In most cases it was more likely to be derived from *Varanus* than from the crocodile, because the former is present in most of the riverine tsetse haunts in numbers, whereas, except on the Benue River, the crocodile in the dry season is absent or rare. Even on the Benue the crocodiles bask on the exposed sand-banks at a greater distance from the shady places than the fly cares to travel, whereas *Varanus* is found basking in trees.

The association of *T. grayi* with the occurrence of non-mammalian blood is illustrated in Table III. It was absent in *G. morsitans*, in which 4.1 per cent. of the recognised blood was non-mammalian; present in 2.3 per cent. of the *tachinoides* in the game areas where 10.1 per cent. of the recognised blood was non-mammalian, but in 9.6 per cent. of this fly in areas where the wild fauna was reduced and an estimated 26.5 per cent. of the food was from non-mammalian sources. It was not found in 413 *tachinoides* examined at Mashiwashi in which only mammalian blood was encountered, and this was a spot where in six months residence we saw no signs of amphibious reptiles. In *G. palpalis* 22.0 per cent. of the recognised blood was non-mammalian and *T. grayi* was found in 2.8 per cent. of the flies. Further, in *G. tachinoides* it was found in 9 (24 per cent.) out of 37 flies which held non-mammalian blood and in only 2 (1 per cent.) out of 195 which held mammalian blood. Similarly in *palpalis* it was found in 4 (20 per cent.) out of 21 flies which held non-mammalian blood and in 2 (2.7 per cent.) of the 74 in which mammalian blood was found. That is, it was common in both species of fly in those individuals which, if one may put it so, were in the habit of obtaining food from non-mammalian sources.

TABLE III.

The Prevalence of *T. grayi* in Tsetse-flies in N. Nigeria and its apparent Association with non-mammalian (mainly reptilian) Blood; shown as Percentages of Number examined.

Fly.	<i>G. morsitans.</i>	<i>G. tachinoides.</i>		<i>G. palpalis.</i>
		Wild ungulates common.	Wild ungulates very scarce.	
Number examined	448	1,093	404	534
<i>T. grayi</i> :—				
Trypanosomes and crithidia	0	1.1	2.0	1.9
Crithidia only	0	1.2	7.6	0.9
Total	0	2.3	9.6	2.8
Percentage non-mammalian blood in total recognised ...	4.1	10.1	26.5	22.0

Finally a brief consideration of the localities where *T. grayi* was most plentiful in *G. tachinoides* affords evidence that if its origin is reptilian it is more probably derived from *Varanus* than crocodile :—

- (1). The River Dingaiya in S. Kano Province, a small stream flowing between mud banks and overhung by trees. Crocodiles are indeed present, but rare, while *Varanus* abounds, its tracks being continually met with and the animal frequently heard though rarely seen. *T. grayi* occurred in 7 (11 per cent.) of 64 flies.

- (2). A long deep pool in the same district near Gwaram, overhung by bushes; crocodiles and *Varanus* both present. *T. grayi* was found in 11 (18 per cent.) of 61 flies.
- (3). A narrow mud-banked stream at Bunga in N. Bauchi Province, water in small pools overhung by trees; *Varanus* present but no sign of crocodiles, for which there was insufficient water. *T. grayi* was found in 12 (27 per cent.) of 44 flies.
- (4). Patta near Gongola River at the eastern edge of Bauchi Province; a small deep rocky pool only a few square yards in extent, heavily shaded; separated from the main river, which was shadeless and tsetse-free, by several miles of dry bush. There was no possibility of crocodiles visiting the spot, but *Varanus* was present, and we saw the tracks of no other animal but man, of whom there was a constant procession fetching water. *T. grayi* was found in 8 (10 per cent.) of 80 flies.

VI. ESTIMATION OF INFECTION BY PROBOSCIS EXAMINATION.

1. Seasonal Variation in Infection.

Proboscis examinations of *G. tachinoides* were continued at Mashiwashi through the rains from the end of April to the middle of October. Examination of the salivary glands was not at this time included with that of the proboscis. Every third week the flies examined were brought from a similar area, Ma-alo, four miles from Mashiwashi, in order to establish a control in case the heavy fly catching or residence at the latter spot affected the figures. The percentages of total proboscis infections discovered, mature and immature, are given in Table IV, divided under periods of three weeks in order to contrast the two localities. Only the mature infections were mounted, so that the proportion of *T. vivax* and *T. congolense* among the immature infections is not known. They are, however, mostly the former, as in the latter the period between the invasion of the labial cavity and the maturing of the infection is a brief one, while *T. vivax* undergoes its whole development there and, in any case, is the more common of the two parasites in the fly.

TABLE IV.

The Trypanosome Infections of G. tachinoides in two similar Localities in the Wet Season, showing the relation between Nutrition and Breeding, and the Effect of a Disturbance and Fly Catching at one Spot; all in Percentages.*

Locality.	Mashiwashi.			Ma-alo.	
	Females pregnant.	Flies well nourished.	Proboscis Infections	Females pregnant.	Proboscis Infections.
Total examined ...	11,540	906	1,366	3,115	900
Periods:—					
23.iv.-15.v ...	67	72	18.3	—	—
16.v.-4.vi ...	30	37	4.1	30	—
5.vi.-25.vi ...	40	—	6.5	51	21.0
26.vi.-16.vii ...	22	32	13.5	24	19.0
17.vii.-6.viii ...	15	34	15.0	28	24.0
7.viii.-27.viii ...	19	34	20.0	20	17.0
28.viii.-17.ix ...	20	—	8.0	21	17.0
18.ix.-15.x ...	23	14	11.3	26	13.5

* The data for the full year are given in Bull. Entom. Res. (4).

The two areas show considerable contrast. At Ma-alo the total infections were fairly constant, with a tendency to drop towards the end of the rains. At Mashiwashi they begin with a high figure, 18.3 per cent., corresponding to the Ma-alo figures, and in the next two periods there was a considerable drop to 4.1 per cent. and 6.5 per cent. respectively, followed by a rise which brought them again into correspondence with

Ma-alo. We have shown elsewhere (4) that *G. tachinoides* has a very definite breeding season which, like that of *G. morsilans* (13), is in the drier part of the year. As the rains progress the rate of breeding is much reduced, and this is probably the automatic effect of the scattering of the food of the fly from the more permanent water, while the growth of long grass and herbs makes what food remains more difficult to find. The flies obtain enough food for their own nourishment, but insufficient to nourish larvae also. Pregnancy was shown to be in relation to food supply by examination of gut contents. Now work was commenced at Mashiwashi just at the beginning of the rains, and the rate of pregnancy fell in the first three weeks as follows:—79 per cent., 74 per cent., 46 per cent. female flies pregnant. There was a rise in pregnancy in June in both localities probably owing to a long break in the rains in May, when the new grass and softer herbs withered. In the first four weeks a large number of labourers were engaged in building and were constantly traversing the kurumi (the denser forest in and about which the fly is localised), and almost perpetual drumming was kept up. This must have had a temporary disturbing effect on the small ungulates, and the flies had an unusual alternative supply of food in the labourers, and certainly took advantage of it. In addition to this, at the beginning the fly boys always caught the flies in the outskirts of the village, which was in a clearing of the kurumi. In mid-June they found a difficulty in obtaining a supply quickly and moved to other parts. Following on this move there was an immediate rise in proboscis infection in one week from 3.0 per cent. to 6.5 per cent. and in the pregnancy rate from 32 per cent. to 66 per cent. The most reasonable explanation of the sudden drop in infection seems to be that owing to intense local catching they were bringing in an unjust proportion of young flies which were still emerging in numbers in May. However, it was not seen how the figures were tending until it was too late to carry out experiments which might have discovered the reasons for the sudden fall and rise. At the end of May the labourers left and the kurumi became quiet and normal.

TABLE V.

The Proboscis Infections of G. tachinoides in two similar Localities in the Wet Season, showing a Seasonal Variation in the Occurrence of T. vivax and the Disappearance of the Immature Infection as the Rains progress; all Figures in Percentages.

Month.	Locality.	Number of Flies Examined.	Total Infections, Mature and Immature.	Mature <i>vivax</i> Group.	Mature <i>congolense</i> Group.	Mature Unidentified, (probably <i>brucei</i> Group)	Total Infections, Mature.	Percentage Mature in Total Infections.
April ...	Mashiwashi	100	17.0	4.0	0	0	4.0	23
May ...	"	346	10.1	1.7	0.3	0	2.0	20
June ...	"	250	6.4	0.4	1.2	0	1.6	25
" ...	Ma-alo ...	400	20.5	3.2	3.2	0	6.4	32
July ...	Mashiwashi	250	14.0	3.2	3.6	0	6.8	48
" ...	Ma-alo ...	100	24.0	7.0	2.0	0	9.0	38
August ...	Mashiwashi	150	17.3	8.7	2.7	0	11.4	65
" ...	Ma-alo ...	170	15.8	12.3	1.7	0	14.0	89
September ...	Mashiwashi	150	7.3	5.3	0.7	0	6.0	82
" ...	Ma-alo ...	130	15.4	10.0	3.1	0	13.1	85
October ...	Mashiwashi	100	14.0	12.0	1.0	0	13.0	93
" ...	Ma-alo ...	100	14.0	10.0	2.0	1.0	13.0	93

Allowing for the experimental factor just described, there is no great variation in the total infections in the proboscides of the flies through the rains, but there is no doubt about the gradual disappearance of the immature infection, as Table V shows. In this table the infections from the two localities are analysed and given as percentages under the various groups of trypanosomes. One infection probably of the *brucei-gambiense* group is included, the infective forms, which were moderately numerous, closely resembling those of this group which are illustrated by other workers. The last column gives the percentage of mature infections to the total infections found. The figures show clearly the manner in which the immature infection begins to become scarce after the heavy rains of July set in and almost disappears towards the close of the wet season in October.

This correlates with our knowledge of the breeding season as outlined above. The average age of the flies is increasing through the rains. The infections mature or die out and relatively few new ones are being acquired, since relatively little ungulate blood is being obtained. Bushbuck, the two species of duiker, and wart-hog were known to be in touch with the fly through the rains, but no sign of the larger antelopes was seen near the kurumi after June. From July onwards occasionally *tachinoides* were encountered in the deciduous forest and no doubt came into contact with the larger animals, but these were the merest stragglers from the main body of fly, which never left their dry season haunts.

The proportion of flies carrying mature *T. congolense* infections fluctuates considerably in the various months. The proportion carrying mature *T. vivax* infections shows a steady increase in both localities as the rains reach their climax and draw to a close.

According to previously made plans, Mashiwashi was left at the beginning of the dry season, November was spent in travel, and in December a new base camp was commenced at Sherifuri, near Azare, a spot briefly described above. In November only two proboscis infections were encountered in 400 *G. tachinoides* examined, so no figures bearing on seasonal variation can be given for this month. From the beginning of December the proboscides of this fly were being examined at the rate of some 700 a month and many infections were discovered. In December 58 per cent. of 33 infections were mature, and the proportion remained about 60 per cent. during the three following months. In November the emergence of the new season's flies was just beginning, and from December onwards a considerable dilution of the old flies with young ones was occurring. The reappearance of the large proportion of immature infections in dissected flies thus coincided with the resumption of active breeding and, of course, increased nourishment of the flies. This tends to show that the explanation of the cause of the seasonal variation is a correct one—but the figures come from two areas with differing climatic conditions, and the argument is less conclusive than it would be if the examinations had all been done at the same spot. Clearly a full year's figures from one locality are required.

In the literature of the tsetse-borne trypanosomes there is little information about seasonal variation in infectivity of the flies. Kinghorn and Yorke (2) working with the infection of *G. morsitans* with *T. rhodesiense* in the Luangwa Valley found in the cold dry season no infective fly in 790 examined by feeding them on laboratory animals, but in the hot part of the year, which included the rains, they found six infective in 804 flies. Bruce and his co-workers in Nyasaland (1), speaking of the trypanosome infection generally of *G. morsitans*, state: "It will be seen that these infective flies occur all the year round, and are just as numerous during one season as another." This statement was based on a series of experiments in which each experimental animal was bitten by about 180 flies, and their summarised figures are quoted in our introduction.

The method of estimation is admittedly not accurate and one experience of our own which illustrates this will be quoted. In the kurumi at Mashiwashi 300 *G.*

tachinoides were collected and fed on a sheep, every fly taking a full meal. The feeding was done on 8-9.vii., and on 23.vii. the sheep developed a *T. congolense* infection. It died of the disease 19 days later and no *T. vivax* was seen in its blood in daily examination. From 4 to 11.vii., 200 *G. tachinoides* collected in the same spot and subjected to proboscis examination showed mature *T. vivax* infections in 2 per cent. and mature *T. congolense* in 3.5 per cent. The sheep was thus bitten probably by some 15 flies with mature infections of the two species of trypanosomes. It is clear from this and other instances that a fly which carries the infective form of trypanosome does not necessarily infect a susceptible animal with every bite it inflicts on it. It is for this reason, and because the percentage infections we record in some cases so greatly exceed those given by previous workers, that we have hesitated throughout to use the term "infective fly" and have spoken rather of "mature infections."

2. Comparisons of Infection in Various Areas.

From the findings in the complete dissections of the flies it was clear that there was a great variation in infection in different localities, but the small number dissected in any one locality made it difficult to contrast them in pairs. Contrasting them in groups was possible but not very satisfactory, as local conditions differ so much. For instance, in one spot may be abundance of baboons and big game and in another the latter may be present without the former, while amphibious reptiles may or may not occur in either case. By using the data obtained from the proboscis only, such contrasts become more possible as the following cases show:—

At the end of the rains of 1922 a visit was paid to the Dingaiya Valley in order to obtain information about the present situation there as regards sleeping sickness, an epidemic having ravaged the valley a few years ago. The affected settlements had been voluntarily abandoned and there was no news of fresh outbreaks. Proboscides of 408 *G. tachinoides* were examined during the ten days spent in the neighbourhood as follows:—

(1). The pool near Gwaram runs in part parallel with an important road and the whole neighbourhood is densely populated. Cattle feed in numbers around the pool. Hippopotamus are often present, but there is no sign of any large antelope, even wet season spoor being absent. A few small antelope occur. As indicated above, the fly has a large non-mammalian source of food. The proboscides of 100 flies were examined on 18-19.xi., and no infections, mature or immature, were discovered.

(2). On the Dingaiya River also a large reptilian food supply is available. The population actually on the banks is small now, though it has been much larger. There are still extensive farms abutting on the stream, which is also much fished by large gangs of men. Cattle graze along the bank. Large antelope occur north of the river, but probably only visit it at night. A few wart-hog were seen in one spot on the bank at mid-day. Baboons are very numerous. The proboscides of 135 flies were examined on 20-25.xi. and no infection was found.

(3). The Dingaiya River flows into the large River Messau near Baserka, a considerable stream with its banks densely populated and almost entirely farmed. A dense thicket some 100 yards in breadth and 300-400 yards long was found on the steep mud banks of a tributary stream. Water had ceased to flow but the mud was still wet. There were signs of some wart-hog and baboons and a few small antelope, while the wet season tracks of one roan antelope were seen. The whole of the grass around the thicket was beaten down by cattle, which grazed here in great numbers. *G. tachinoides* was numerous; 155 proboscides were examined on 24-27.xi., and one immature and one mature infection (*T. vivax*) were discovered.

In this locality therefore *G. tachinoides*, a fly of very catholic tastes, has access to a large bulk of food in man, cattle, baboons, large reptiles and an insignificant number of wild ungulates.

The proboscides of 0.5 per cent. of the flies contained trypanosomes and mature infections were found in 0.25 per cent. At Mashiwashi and Ma-alo in the previous month the proboscides of 14 per cent. of 200 *G. tachinoides* contained trypanosomes and mature infections were found in 13 per cent. In this case domestic animals, baboons and amphibious reptiles were absent; man was scarce; but the fly was in intimate contact with wild ungulates.

A similar contrast in the infections of tsetse in different parts of what would have been considered a small uniform fly area is being found at Sherifuri.

Here local conditions are very peculiar. In some parts of the area *G. tachinoides* is a very clean fly, the rate of total proboscis infection being as low as 1.0 per cent. in 1,070 flies, and in others as high as 10.6 per cent. in 980 flies, while in certain intermediate spots the figure is 4.1 per cent. in 560 flies. *G. morsitans* shows a similar variation of proboscis infection. In one part of the area the infection rate has been 16.9 per cent. for 883 flies and in others it reaches the very high figure of 45.2 per cent. in 560 flies. These variations have occurred in a piece of country less than five miles across and have been roughly constant in each of the first four months of our work there. They indicate among other things that the flies are not passing with any facility from focus to focus. Any attempt to analyse them at present would entail a very long description of the different parts of the area, and this would necessarily be inadequate until a year's residence has familiarised us with the seasonal movements of game and other local conditions.

VII. SUMMARY AND CONCLUSIONS.

This paper has been written to describe a new method of rapid estimation of trypanosome infection in tsetse-flies and to show the possibility of obtaining important information by it rather than as a record of any knowledge which has been gained while it was being developed. By means of a dissection which yields the proboscis fully displayed and the important parts of the salivary glands in one preparation, all mature infections of the *vivax* and *congolense* groups of trypanosomes may be discovered and most of the *brucei-gambiense* group. It gives no information as to the pathogenicity of the parasites and does not serve to distinguish between such morphologically similar species as *T. brucei* and *T. gambiense*. These are great drawbacks which can only be overcome by the use of elaborate fly-feeding experiments. Compared with these latter, however, it is a much less cumbersome method, and in the main as rapid, while it yields, within its limits, more accurate statistics. By these it is possible to study the infection in the fly in relation to animals with which it is in contact and in various ways light is thrown on the bionomics of the insect.

The method is sufficiently sensitive to record at once the effect of any change in local conditions. An instance of this occurred at Mashiwashi when the disturbance in a patch of dense forest due to building and a certain amount of fly-catching reduced the proboscis infection in one part from 18.3 to 4.1 per cent. within six weeks, to be followed by a corresponding rise after the disturbance ceased.

There is an indication that in at least one of the pathogenic trypanosomes (*T. vivax*) an important seasonal variation in the proportion of infective flies (*G. tachinoides*) occurs, the mature infections increasing as the rains progress.

Variations in the infections of *G. tachinoides* and *G. morsitans* in different parts of a very small area have been found by the proboscis examination. To have discovered this so fully by means other than quick dissection would have entailed carrying out a series of fly-feeding experiments from each of ten foci in the case of *G. tachinoides*, and from each of three fixed spots in the case of *G. morsitans*—an impracticable undertaking.

A comparison of the infectivity of the three prevalent species of tsetse for the country generally is given. *G. morsitans* is much more heavily infected with the main

cattle-inhibiting trypanosomes (*T. vivax* and *T. congolense*) than is *G. palpalis* or *tachinoides*.

It is also shown that the infection in *tachinoides* is heavier in spots where the wild ungulates are prevalent than in places where they are scarce. Where *G. morsitans* and *tachinoides* range together the infection in the former is double, or more than double, that in the latter. This is probably because *G. tachinoides* has no special predilection for ungulates as hosts.

Some notes on the non-pathogenic *T. grayi* are included, with evidence that it is reptilian in origin.

VIII. APPENDIX. TRANSMISSION EXPERIMENTS WITH *G. tachinoides*.

Trypanosoma vivax.

EXPERIMENT IV. 22.vii.22—19.viii.22.

24 laboratory-bred flies were fed for two consecutive days upon goat No. 29 infected with *T. vivax* by wild *G. tachinoides* and showing very numerous trypanosomes in the peripheral blood. They were then starved for two days and were subsequently fed on clean goat No. 42 for 21 days. On the last day of feeding goat No. 42 developed an infection of *T. vivax*.

23 flies survived and were dissected upon the 26–27th day after the first infecting meal; 13 of the flies were negative; 1 had a single trypanosome fixed in the labrum, undoubtedly acquired from goat No. 42 at the last meal; 9.39 per cent. had the labial cavity heavily infected, with infective forms in the hypopharynx in each case.

Result positive, 9 mature infections being found.

EXPERIMENT V. 15.viii.22—2.ix.22.

30 laboratory-bred flies received two feeds on consecutive days and 18 received one feed on goat No. 47, infected with the same strain of *T. vivax* as goat No. 29 of Exp. IV after passage through an intermediate goat No. 41. At the time of feeding the goat showed very numerous trypanosomes in the peripheral blood. They were then starved for one day and in some cases two days and were dissected at varying intervals, being fed in the meantime on clean goats, and from the eighth day after the first infecting meal on clean goat No. 50 till 3. ix.22. On 4. ix.22 goat No. 50 developed an infection of *T. vivax*.

(A) One infecting meal.

Four flies were dissected the day after infection. All showed trypanosomes more or less active in the mid-gut and in one case in the proventriculus. In two the proboscis was negative and in two a few trypanosomes were attached to the labrum.

Four flies were dissected 2 days after infection. One had a few sluggish trypanosomes in the hind part of the mid-gut and a single amotile spindle form attached to the labrum. Two were negative throughout, and in one the gut was negative and there were two groups of 7 and 12 flagellates respectively attached to the labrum.

Four flies were dissected 3 days after infection. One was negative throughout; one had the gut negative, but a few sluggish degenerating trypanosomes were present in the crop, the proboscis being negative; the remaining two had the gut negative and proboscis positive, the colonies containing forms too numerous to be counted.

Six flies were dissected 4 days after infection and five were negative throughout; the other had the gut negative and two colonies attached to the labrum.

(B) Two infecting meals.

Two flies were dissected 5 days after first infection. One had numerous degenerating trypanosomes in the crop and a few in the mid-gut, the proboscis being negative; this fly was unhealthy, the proboscis being clogged with a fungous growth, and it had not fed since infection. In the other fly the gut was negative and a single colony was attached to the labrum.

Two flies were dissected 6 days after first infection and were negative throughout.

Two flies were dissected 7 days after first infection, and one was negative throughout; the other had the gut negative and a single colony attached to the labrum.

One fly was dissected 10 days after first infection and had the gut negative and three colonies attached to the labrum.

One fly was dissected 11 days after first infection and had the gut negative and had large colonies attached to the labrum.

Two flies were dissected 12 days after first infection and were negative throughout.

Seven flies were dissected 13-18 days after first infection. One was negative throughout and the remaining six all showed heavy infection of the labial cavity, the large majority of the organisms being fixed in colonies, with few free swimming. In each case the hypopharynx contained trypanosomes.

The earliest invasion of the hypopharynx was thus on the 13th day after the first infection and occurred on 28th August. The goat which was feeding the flies developed *T. vivax* on 4th September, 7 days after the hypopharynx was invaded. The incubation period of this strain of trypanosome in 8 goats averaged 8 days (6-14 days). From this it appears that the flies became infective about the 13th day after infection and that the onset of infectivity coincided with the invasion of the hypopharynx.

Result positive, 6 mature infections being found.

Trypanosoma congolense.

EXPERIMENT XIV. 15.v.23—1.viii.23 (flies infected in series).

68 laboratory-bred *G. tachinoides* fed for six successive days upon dog No. 72 and goats Nos. 74, 81, 86, 95 infected with *T. congolense* from wild *G. tachinoides* and *morsitans*. Before dissection they fed upon clean goat No. 96 which developed *T. congolense* 11 days later.

30 flies dissected 28-30 days after first infecting meal showed two mature and one immature infections with *T. congolense*. In all three infected flies the gut, proventriculus and proboscis showed infection, the proboscis containing trypanosomes of the proventricular type and crithidia, and in the two mature infections the hypopharynx contained trypanosomes of the infective type; the 38 remaining flies dissected 15-26 days after first infection proved negative.

Result positive, mature infection by *T. congolense* being found in two out of 68 flies and transmission being made to a clean animal.

EXPERIMENT XV. 4.vi.23—17.vii.23.

101 clean flies, as used in Experiments XII and XIII, fed upon goats Nos. 81 and 74 infected with *T. congolense* (wild *G. tachinoides* strain). Numbers 1-60 had three infective meals on alternate days and numbers 61-101 received six infective meals on successive days. The flies fed before dissection upon clean goat No. 95, which developed *T. congolense* 13 days later.

The flies were dissected 29-31 days after first infective meal. Numbers 1-60 showed two mature infections; numbers 61-101 showed three mature infections. In all infected flies flagellates were present in gut, proventriculus and proboscis, and the hypopharynx contained trypanosomes of the infective type.

Result positive, mature infection being found in 5 out of 101 flies and transmission being made to a clean animal.

Trypanosoma gambiense.

EXPERIMENT X. 10.iii.23—26.iv.23.

47 laboratory-bred flies received two feeds, and 4 flies received three feeds, upon guinea-pig No. 62 infected with *T. gambiense* from a human case of sleeping sickness. The infecting feeds were upon alternate days, the flies feeding on the intermediate days and thenceforward upon clean goat No. 65. The flies fed upon clean monkey No. 73 on the day before dissection.

The flies were dissected 24–26 days after first infection. One fly showed infection of gut and proventriculus and one showed infection of gut, proventriculus and labial cavity, the latter containing trypanosomes of the proventricular type. No invasion of the salivary glands was discovered.

Monkey No. 73 developed *T. gambiense* on the eighth day after feeding the flies; goat No. 65 remained uninfected.

Result positive, but mature infection of fly not discovered.

EXPERIMENT XII. 27.iv.23—15.vi.23.

41 clean wild flies, from a locality from which 650 flies were dissected between February and June 1923 and proved uninfected by any pathogenic trypanosome, received three infective feeds on alternate days upon guinea-pig No. 62 as used in Exp. X, and were afterwards fed upon clean goat No. 65.

The flies were dissected 30–34 days after first infecting meal. One fly (on 34th day) showed infection of gut, proventriculus, labial cavity and salivary glands. The labial cavity contained scanty trypanosomes of the proventricular type; the salivary glands showed numerous crithidia and trypanosomes of the infective type.

Result positive, one mature infection being found.

EXPERIMENT XIII. 8.v.23—22.vi.23.

16 clean wild flies from the same locality as those used in Exp. XII fed for three alternate days upon monkey No. 73 infected with *T. gambiense* by the laboratory-bred flies used in Exp. X.

The flies were dissected on the 32nd day after first infecting meal. One fly showed infection of gut, proventriculus, proboscis and salivary glands. The proboscis contained only scanty trypanosomes of the free-swimming proventricular type; the salivary glands contained scanty crithidia and very numerous trypanosomes of the infective type.

Result positive, one mature infection being found.

Trypanosoma brucei.

EXPERIMENT XVI. 22.vi.23—15.viii.23.

67 clean wild flies from the same locality as those used in Exp. XII fed in series for three successive days upon dogs Nos. 90 and 93 infected with *T. brucei* (wild *G. morsitans* strain). On the day before dissection they fed upon clean monkey No. 102, which developed *T. brucei* 8 days later.

Two flies were dissected upon death on the 10th day after the first infection and trypanosomes were found in the gut of one; 45 flies were dissected on the 31st–32nd day after first infection and infections were found in two of these; in both, the gut and proventriculus contained trypanosomes, and scanty free-swimming trypanosomes of the proventricular type were present in the proboscis; in one the salivary glands contained trypanosomes of the infective type and scanty crithidia, in the other the salivary glands were not invaded.

Twenty flies were dissected on the 40th day after first infection, and of these four flies proved to be infected. In two the gut, proventriculus and salivary glands were heavily infected, and scanty trypanosomes of the proventricular type were found in the proboscis. The salivary glands contained active flagellates in large numbers, which proved to be crithidia, preinfective forms and infective trypanosomes. In two the gut, proventriculus and proboscis showed infection as above, but the infection was not heavy and the salivary glands showed no actively moving flagellates. Teased and stained preparations of the glands, however, demonstrated scanty crithidia and in one fly scanty infective trypanosomes.

Result positive, five mature and one nearly mature infections being found in the flies and transmission being made to a clean monkey.

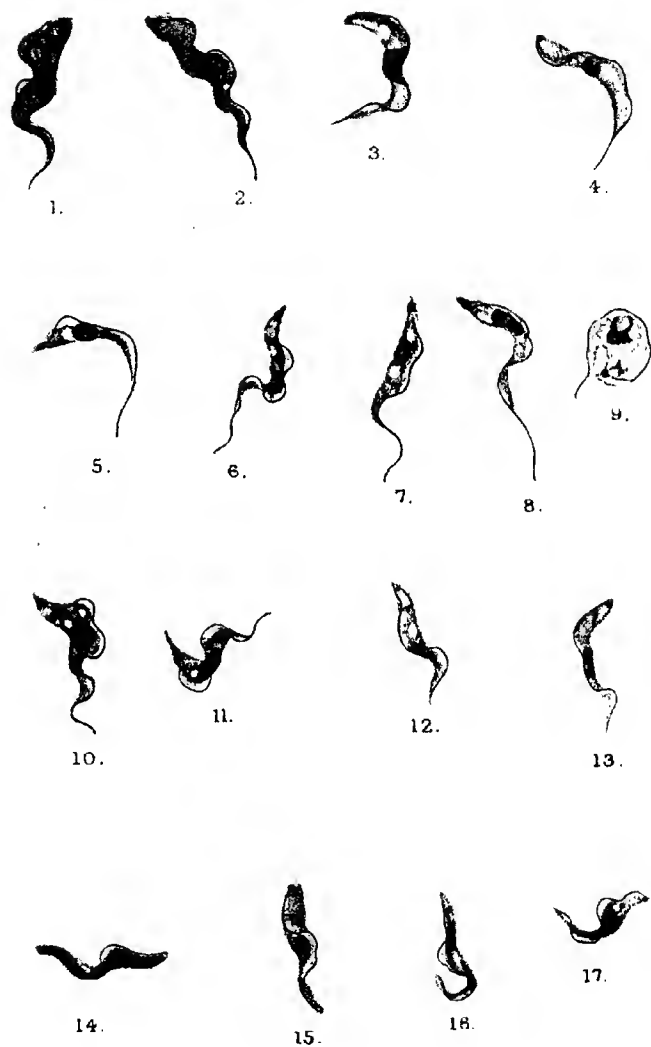
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EXPLANATION OF PLATE XXIII.

Infective Forms of Trypanosomes. $\times 2000$.

- Figs. 1-2. *T. brucei* in salivary gland of *G. tachinoides* (lab. infection).
3-4. *T. gambiense* in salivary gland of *G. tachinoides* (lab. infection).
5-6. *T. vivax* in hypopharynx of *G. tachinoides* (lab. infection).
7-9. *T. vivax* in hypopharynx of *G. palpalis*.
10-11. *T. vivax* in hypopharynx of *G. morsitans*.
12-13. *T. congolense* in hypopharynx of *G. tachinoides* (lab. infection).
14-15. *T. congolense* in hypopharynx of *G. palpalis*.
16-17. *T. congolense* in hypopharynx of *G. morsitans*.



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Infective Forms of Trypanosomes found in
various Species of *Glossina*.

EXPLANATION OF PLATE XXIV.

Characteristic Forms of Trypanosomes from Gut of *G. tachinoides*. $\times 2000$.

- Figs. 1-3. *T. brucei* in mid-gut (lab. infection).
- 4. *T. brucei* in proventriculus (lab. infection).
- 5-8. *T. congolense* in mid-gut (lab. infection).
- 9. *T. congolense* in proventriculus (lab. infection).
- 10-13. *T. grayi* in mid-gut.
- 14. *T. vivax* in mid-gut, degenerate.
- 15. *T. vivax* in crop, degenerate.



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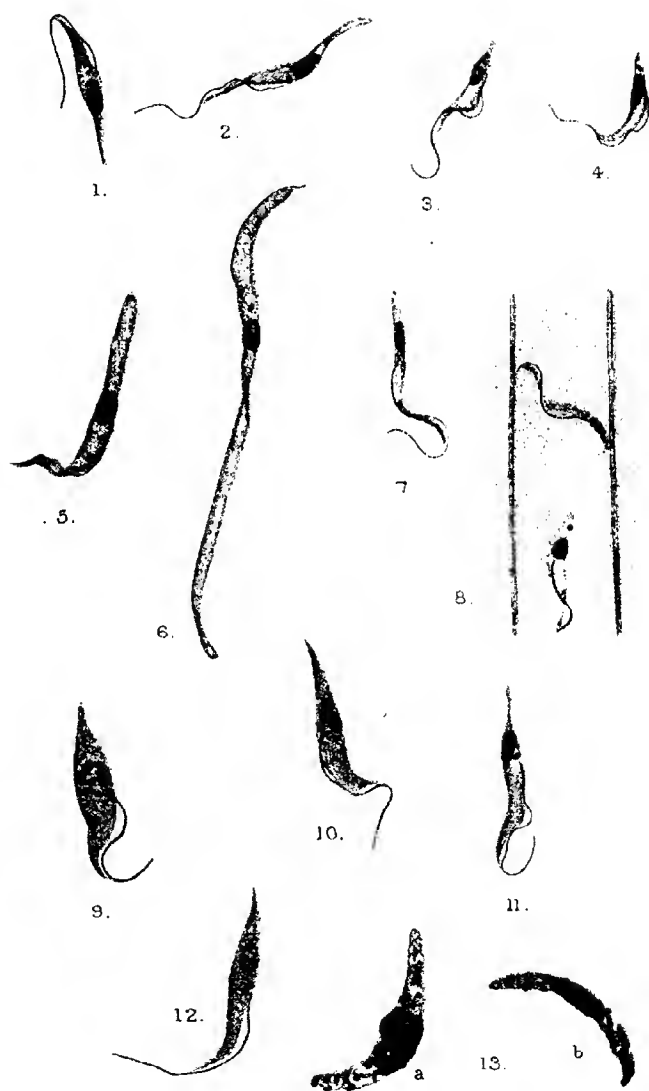
Path. Order

Characteristic Forms of Trypanosomes from
Gut of *Glossina tachinoides*.

EXPLANATION OF PLATE XXV.

Characteristic Forms of Trypanosomes from Proboscis and Salivary Glands of
G. tachinoides (lab. infections, except fig. 13). × 2000.

- Figs. 1-2. *T. vivax* crithidia from fixed colonies in labial cavity.
- 3-4. *T. vivax* preinfective or transitional forms.
- 5-6. *T. congolense* crithidia from fixed colonies in labial cavity.
- 7. *T. congolense* free-flagellated preinfective or transitional form.
- 8. *T. congolense* preinfective and infective in hypopharynx.
- 9, 10, 12. *T. brucei* crithidia in salivary gland.
- 11. *T. gambiense* crithidia in salivary gland.
- 13. Haemogregarines commonly associated with reptilian blood in mid-gut of *G. tachinoides*.



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Edin, London

Characteristic Forms of Trypanosomes from Proboscis
and Salivary Glands of *Glossina tachinoides*

APPLIED ENTOMOLOGY OF PALESTINE, BEING A REPORT TO THE PALESTINE GOVERNMENT.

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(PLATES XXVI-XXX.)

	Page.
I.—Introduction	289
1. The Country	290
2. The Climate	292
3. The Fauna	293
II.—Anophelines and Malaria	294
1. Breeding-places of Anophelines	295
2. Association of the Species	296
3. Seasonal Occurrence	299
4. The Rural Species in relation to Man	300
5. The Domestic Species	303
6. Results of Dissection	304
7. Artificial Control	304
8. Natural Control	307
9. Notes on the Species	309
10. The Malaria	312
III.—Other Arthropods of Medical and Veterinary Interest	314
IV.—Agricultural Pests	331
V.—References	338

I. INTRODUCTION.

In the pages which follow I record some observations which I made upon the insect pests of this extremely interesting country while I served the Palestine Government as Medical Entomologist (May 1921 to August 1923). I have divided my notes into three parts. The part which deals with *Anopheles* and malaria is the fullest; that which deals with some other creatures of medical and veterinary interest is incomplete, and it must not be supposed that an insect is absent or even rare because I have not found it; that which deals with the pests of crops and plants is extremely fragmentary.

The identifications have invariably, even in the case of the commonest insects, been made in England by the specialists who collaborate with the Staff of the Imperial Bureau of Entomology. To all of them, and they are too numerous to mention individually, my thanks are due, as they are to Prof. G. H. F. Nuttall, F.R.S., and the Staff of the Molteno Institute, Cambridge, who have examined my ticks, and to Mr. J. T. Sanders, of Christ's College, for helping me with the technique of hydrogen ion measurements. In Palestine very many people, official and otherwise, have assisted me generously: Drs. R. Briercliffe and G. Stuart of the Directorate of Health, with statistics; the Malarial Survey Section of the International Health Board (Dr. P. S. Carley and Mr. J. Mieldazis) and the Malaria Research Unit (Dr. I. J. Kligler), with innumerable specimens and notes; Dr. F. Bodenheimer and Mr. I. Aharoni, and Mr. G. E. Bodkin of the Department of Agriculture, with material of various sorts; Drs. Tucktuck, Abu Ghazaleh, Herbert Torrance and Thompson, with larvae from human cases of myiasis; Mr. A. Wilson, Assistant Sanitary Surveyor, with mosquitos and the results of his experiments on *Cyprinodon*; Miss W. Masterman, with her drawings of olive leaves (fig. 8); and Mr. K. K. Daghljan, Senior Attendant in the Central Laboratory, Jerusalem, by examining blood films. I wish also to express my thanks to Mr. F. Vester of the American Colony, Jerusalem,

for permission to use the photographs which appear as Plates xxvii—xxx. Mr. Oskar Theodor, who has worked with me for a year, is a gifted entomologist and artist, as his own paper on *Culicine* pupae (page 341) shows; he is also a most hardworking and reliable assistant.

In the spelling of place names I have, I hope, followed the newer system of the Geographical Society ("R.G.S. II"). No system is perfect, and none will meet with universal acceptance, but it seems unlikely that a better system for general purposes will be produced.

The drawings from which the text-figures are made are my own, except where the contrary is stated.

1. The Country.

Palestine is a country of varied physical features, and varied climate, and is pushed out into the desert as if it were an outpost of Europe and Western Asia. It is bounded (see Map, p. 340) westwards by the Mediterranean Sea; northwards a line passing from the Ladder of Tyre (Ras en Nakura) to Metullah and Banias separates it from the French Mandatory Territory of Syria; the southern boundary is a line joining Rafa on the Mediterranean to a point at the head of the Gulf of Akaba; the eastern boundary follows roughly but not exactly the line of the River Jordan and its lakes, but includes in Palestine the whole of Lake Huleh and of the Lake of Tiberias (Sea of Galilee), and certain small areas on the eastern bank of the River Jordan below this point. Beyond this eastern boundary lies land which is very similar to Palestine in physiography and natural history. The northern part of it is administered by France, the southern is "Transjordan," a somewhat indefinite area which has been recently declared independent. Within these narrow boundaries lies Palestine, a small country which exhibits as great a diversity of scenery, climate, and fauna as any land of the same size.

The coast of Palestine is extremely regular, broken only by the rocky headlands of Carmel, and of the Ladder of Tyre (Ras en Nakura) at its extreme northern limit. Its only harbours accommodate nothing larger than a small sailing boat; such as they are, they have some interest to the entomologist because they trade regularly with Egyptian ports, particularly in July when there is a great export of water-melons from Palestine. In the Mediterranean ports of Egypt plague is endemic, and nearly every summer it makes its appearance in Haifa or Jaffa.

If one enters Palestine by sea at Jaffa, or by rail from Egypt, one encounters first of all a belt of sand-dunes, which are continuous or nearly so along the coast, and in several places expand to a width of two to three miles. This dune area is not entirely barren, for in the hollows good water may often be obtained within a few feet of the surface. Such places are sometimes planted with grape-vines and with water-melons; the great dune area south of Jaffa supports a small population of Bedouin. Apart from the fact that these dunes cover land which could otherwise be fully planted, they are of great importance because they block the mouth of every river and winter torrent that should enter the Mediterranean, and these drainage channels are numerous and important, because they carry off water from at least two-thirds of Palestine. As their mouths are blocked by dunes they form a chain of marshes, some large and permanent like those of the Rivers Kishon, Zerqa, Rubin and Ghuzze (Plate xxvi); others, which are too numerous to mention, temporary and depending upon the winter rains for their extent and for the period during which they endure before they dry up. The damaging effect of dunes is supplemented at many places between Carmel and Gaza by parallel ridges of sandstone, probably Pliocene, lying within a few hundred yards of the coast. The very considerable malaria at Athlit, Tantura, Caesarea and other places is apparently due to winter rain collected on the landward side of these ridges. Behind the dunes lies the Coastal

Plain, extending the whole length of the country from south to north, save where it is broken by Mount Carmel; in width it varies from about four to upwards of twenty miles. At Haifa it extends eastwards as the Plain of Esdraelon across the centre of the country, and here it is continuous with the Valley of Jezreel, which contains a tributary of the Jordan. Except at this point the Coastal Plain passes gradually into the hill region which forms the backbone of the country.

The Coastal Plain consists of Pleistocene sands and gravels, and of debris washed down from the hills, being flat and extremely fertile; it supports a large indigenous population of villagers, and a considerable number of colonies of immigrant Jews. The villages and colonies present many points of contrast. The native of the country is still primitive in his methods and conservative in his ideas; his implements are ramshackle and his seed may be poor, but he manages to exist, and frequently to accumulate wealth; he shows considerable power of learning, and appreciates the advantages of hygiene and of improved methods of agriculture. The "colonist," on the other hand, is generally town-born, or the child of town-born parents; he is supported in part by funds subscribed abroad and in part by a very genuine idealism; his implements are good and modern and his crops are better than those of his neighbour, but without his subsidy he would be hard put to it to exist; he is sometimes so pleased with the results of his labour that advice relating to insect pests or to hygiene is wasted upon him, at any rate if it is offered by a Gentile.

The crops grown in the Coastal Plain are wheat and barley as winter crops, great millet, water-melons, sesame and pulse in summer. There are plantations of almonds in many places and of oranges near Jaffa; figs, olives, apricots and many other fruits are grown on a small scale. Hedges of *Opuntia* and of *Acacia farnesiana* are used.

Passing eastwards we leave the gravels and sandy soil of the Coastal Plain and enter country in which Upper Cretaceous limestone reaches the surface. The limestone hills rise gradually through a region of foothills to the highlands of Judaea, Samaria or Galilee, and fall much more steeply on the east to the Jordan Valley. They form an irregular complex of rounded hill-tops, few of which pass 3,000 feet, and abrupt tortuous valleys. The main water-shed of the country is difficult to distinguish, but passes through Jerusalem and Nablus. Throughout this country the limestone reaches the surface so frequently that it imparts a general grey tone to the landscape, except in spring, when the land is covered with flowers and grass. Soil is scanty, and deep soil is only to be found in the valleys or on the terraces on the hill-sides, supported by stone walls. It is sometimes supposed that Palestine lies waste, awaiting only the return of the Jews to make it blossom like a rose; as a matter of fact the country is already cultivated almost to the limit of what is possible, a limit imposed by uncompromising outcrops of bare limestone and by the drought of summer. The population of the hill-country is nearly all settled in villages and small towns; the sites of these places, many of which are easily defended, is determined either by springs, which are rare, or much more often by the rock-cut cisterns. These cisterns are excavated in the soft limestone and rendered water-tight with cement; in winter they fill with rain-water collected by the roofs of the houses and off the village street. In the hills, at any rate, they are the essential feature of the life of the villager; houses may be burnt or may crumble, but rock-cisterns endure almost for ever, and round and over them the village continues to be rebuilt time and again. From this it follows that many of the village sites were already old when Joshua entered the land, and many of them preserve their Old Testament names unchanged. The hill villagers grow more tree-crops and fewer field-crops than the men of the plains. Great groves of olives extend round many of the villages, and at Nablus large quantities of soap are made from olive oil and the ashes of the "kali" plant, from which the word alkali is derived; figs and apricots are abundant; quinces, mulberries and almonds not uncommon. The hill-terraces are planted with vines, especially in Judaea, and as the majority of the villagers are Moslems the crop of

grapes is turned into raisins and not into wine. Cereals are grown wherever the plough can be used, in the valley bottoms and on the mountain terraces, and many of the villagers go down into the Coastal Plain to help in the more abundant harvest there; some of the hill villages own well-watered lands in the Jordan Valley, and the men go down there to their harvest. These nomadic habits are of interest when the epidemiology of malaria is studied.

The hill-country is generally divided into Galilee, Samaria and Judaea. Galilee is sharply sundered from Samaria by the Plain of Esdraelon, extending across from the Coastal Plain at Haifa to unite with the Valley of Jezreel and then sloping down to the Jordan Valley. Samaria and Judaea are less clearly divided from one another, and so far as crops and people and fauna are concerned there is little difference between the three parts of the highlands. Southwards Judaea passes gradually into the undulating semi-deserts of the Negeb. Here the limestone is again lost to sight, and the surface formation is loess, consolidated wind-driven dust.

The eastern boundary of the hill-country, the Jordan Valley, is sharply defined, and unique in character. The River Jordan rises in a number of springs at Banias at the base of Mount Hermon. After a short course it expands into the wide, shallow Lake Huleh (alt. 6 feet), more than half of which is blocked with a mass of reeds and papyrus into which one can hardly penetrate either on foot or by boat. From Huleh the river descends very rapidly through a gorge, dropping 600 feet in 9 miles to the Lake of Tiberias, which it enters at the Batiha, a marshy area, the rest of the lake being clear water with pebbly shores.

From the point where the Jordan leaves the Lake of Tiberias (680 feet below sea-level) to the point where it enters the Dead Sea (1,290 feet below sea-level) the river runs through a remarkable trough (the "Ghor"), the sides of which are formed by a series of parallel faults. The strip between the two main groups of faults has dropped, and in more recent (quaternary) times has been filled by the Dead Sea, which at one time extended at any rate as far north as the Lake of Tiberias. For this reason the bottom of the depression is covered with a maritime deposit of salt marl, hard and smooth, intersected by numerous tributaries of the Jordan. These tributaries and the Jordan itself cut deep precipitous channels in the floor of the depression (Plate xxvii) and are fringed with a narrow dense belt of *Populus euphratica*, *Tamarix*, *Prosopis* and other scrub. Until very recent years the Ghor has suffered from raiders and robbers, and the settled population is still very small. South of Tiberias and Semakh the first settlement to be seen is the town of Beisan (Bethshan). Within an hour's ride of Beisan there are several villages, but after they are passed there is no village until Jericho is reached. The whole length of the Ghor is parcelled out among small Bedouin tribes, who are principally pastoral, but some of whom are beginning to cultivate barley and wheat. Water is more abundant than in most parts of Palestine. The Jordan itself is so deeply sunk in the channel which its waters have cut that it cannot be used for irrigation without extensive engineering schemes, but many of the tributaries on either bank are perennial and form oases; those of Jericho and Beisan are among the oldest and best known.

2. The Climate.

The physical diversity of Palestine has its counterpart in the climate, which differs widely in places lying within a day's ride of one another; moreover, one must bear it constantly in mind that Palestine is on the borders of great deserts, and therefore its climate is characterised by great deviations from the mean, and the ordinary meteorological information does not give a complete picture of it. For this reason it is useless to quote mean statistics; to exhibit the diversities and irregularities of the climate recourse must be had to the complete tables published in the "Handbook of Syria," which deal not only with monthly and annual means but also with the maxima and minima observed during long periods of years.

Here I must be content to make some general statements. Rainfall in the hills and the north is lighter than in the plains and the south. In amount it is considerable, and Jerusalem has approximately the rainfall of London, but the great part of the rain falls in the winter, as is shown by the following table, which gives the mean monthly rainfalls, expressed as percentages of the mean annual rainfall (Hann):

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
25.3	17.0	12.0	4.9	1.1	0.0	0.0	0.0	0.2	2.4	12.3	24.8

With such a seasonal distribution as this the amount of annual rainfall is of little importance. One sighs for an early and copious "former rain" in October and November to cool the air, lay the dust, and make ploughing possible. One longs fervently for a "later rain" in March or even April, which will increase the barley and wheat harvest, and germinate the millet, melons and sesame, which are sown about the end of April. Rain received in midwinter fills the cisterns and springs, but is less appreciated because in the cold weather vegetation is at a standstill. The lack of rain in summer occurs exactly at the season when evaporation is greatest. This seasonal distribution is characteristic of every part of Palestine, and indeed of the Mediterranean area generally, and no doubt contributes largely to the aridity of this part of the world. In the south of Palestine and in the Jordan Valley below the Lake of Tiberias the aridity is greater than elsewhere, the mean rainfall being lower. In these places country is found which is desert in every sense of the word.

Broadly speaking one may say that the summers are hot in all parts of Palestine, absolute maxima of 100° – 110° F. (38 – 43° C.) being recorded for nearly all stations for which records have been kept for several years. These high daily temperatures are quite bearable, because there is an almost unfailling wind from the west and the humidity is low (about 30–35 per cent. most summer afternoons, in most parts of Palestine). Moreover, the temperature drops very rapidly at sunset, so that the nights are nearly always pleasant. Autumn hardly exists, for even September and October are bright, warm, and almost rainless. Winter begins rather suddenly in November, and may be said to last till February, and in some years March, but though frosts occur and snow falls most years in the hills, the winter is rather the season of rain than the season of cold. The delightful flowery spring lasts from February till May, and at the end of this season the whole face of nature changes, the annual vegetation disappears, and with it many of the insects. In May and June one experiences hot dry winds from south and south-east, and summer has come.

The prevalent wind of Palestine blows from the north-west (or west) at all seasons, but it is relatively commonest in summer, when it springs up almost without fail between 8 and 10 a.m. and blows strongly and steadily all day till sundown. Its value to the country, at a time of day when the temperature is high, is tremendous, and when it fails or is replaced by an east or south-east wind even the hill-country is unpleasantly hot. Such a steady regular wind must be an important factor in dispersing insects and other small creatures, and I am convinced that attention should be paid to it in laying out new settlements; they should be placed up wind of any swamp which cannot be drained, and the main thoroughfares should be parallel with the prevalent wind.

The climate varies greatly in different parts of Palestine; though the differences are too complex to be dealt with here, they are important and must never be lost sight of—for instance, Jerusalem may be buried in snow, or exposed to cold wind and sheets of rain, but at Jericho the sun may be shining, the *Anopheles* breeding in profusion, and the desert covered with blossoming annuals.

3. The Fauna.

Palestine, as I have said, has the desert or the sea as its boundaries, except on the north; and one might speak of a faunistic peninsula, the base of it being Asiatic Turkey, the stem Syria, and the extremity Palestine and parts of Transjordan.

The fauna of the peninsula has, for the most part, entered it through its base, and is therefore Palaearctic, and many of the plants and animals in reaching Palestine have reached the southern limit of their range—for example, the pines and oaks, jays (*Garrulus*), tits (*Parus*), blackbird (*Merula*), which visits Egypt in winter but does not breed there, and voles (*Microtus*).

The great desert which bounds our "peninsula" to east and south has a peculiar fauna, derived for the most part from the Palaearctic Region, but so modified that one has to recognise it as distinct; it contains also a considerable number of species the affinities of which are Ethiopian, and most of these have apparently reached it not through the Nile Valley and Sinai but through the Red Sea. Because Palestine is arid some of the desert types have penetrated it; many occur in the Jordan Valley, the sandy coastal plain, or the parched Negeb; a few have even reached the highlands of Judaea; owing to this and to the extreme diversity of terrain and climate the fauna is very complex and rich, considering the aridity.

The fauna of my own garden at Jerusalem illustrated this—it included a palaearctic hedgehog (*Erinaceus roumanicus sacer*) and shrew (*Crocidura russula judaica*), and a typical mammal of the desert, the spiny mouse (*Acomys dimidiatus*). In and round Jerusalem one may catch *Papilio*, *Thais*, *Pieris brassicae*, *Anthocharis*, *Melanargia*, *Satyrus* and other butterflies, specifically identical in nearly every case with European forms; but one catches also *Teracolus fausta*, one of the most widely spread members of an African genus. Within two miles of Government House on the Mount of Olives, desert larks (*Ammomanes deserti fraterculus*) and linnets (*Acanthis cannabina*) may be found breeding side by side. Among insects of economic importance one finds *Ceratophyllus fasciatus* and *Xenopsylla cheopis*, both living in Jerusalem. Indeed, instances to illustrate the mixed character of the fauna might be multiplied to an indefinite extent.

If we descend towards the Coastal Plain we reach a warmer climate and a sandier soil; the desert fauna is here perhaps more abundant. Voles (*Microtus*) from the north and gerbilles (*Gerbillus*, *Meriones*) from the desert compete for the crops; an African Bulbul (*Pycnonotus xanthopygus*) is as common in the orange gardens as the ordinary goldfinch (*Carduelis carduelis*). *Nemoptera aegyptiaca* is common, and serves to show that one is not far from Egypt.

In the Jordan depression, and particularly in the southern part of it, the African element is prevalent to a remarkable extent. Very familiar examples are the grackle (*Amydrus tristrami*), sunbird (*Cinnyris osea*), fantailed raven (*Corvus rhipidurus*), the Cichlid fishes (*Chromis* and others, abundant in all parts of the Jordan system), and the hyrax or coney (*Procavia syriaca*). Less familiar examples are the African dragonflies *Urothemis edwardsi* and *Pseudomacromia torrida*, the Lycaenid *Iolans jordanus*, and the Culicines *Uranotaenia unguiculata* and *Culex laurenti*. Creatures with African affinities do not indeed predominate, but they form a noticeable element in the fauna, and one must expect that further work will increase the number recorded. The economic entomologist must bear it in mind that an African scale-insect or Tabanid is almost as likely to appear as a Palaearctic one.

II.—ANOPHELES AND MALARIA.

It has been known for many years that the principal disease of Palestine is malaria. Before the war both Masterman and Mühlens described its ravages in the city of Jerusalem, and Cropper made a rapid survey of many parts of Palestine and Southern Syria, estimating its frequency in rural areas and small towns. During and after the war military sanitarians did excellent work in reducing the number of *Anopheles* in areas occupied by the troops, and Lelean & Watts and Barraud published useful memoirs. All these workers and many others showed the extreme importance

of malaria to the health and prosperity of the country. When I reached Palestine in the spring of 1921 it was clearly of first importance to determine which of the nine species of *Anopheles* were of serious importance, and which were not; to that end most of my work for two years has been directed.

1. Breeding-places of *Anophelines*.

A study of the geographical distribution of the species revealed nothing of interest. "From Dan to Beersheba," or as one might say in terms of applied entomology "from Huleh to the Shellal Dam," the mosquitos of any particular type of environment are the same; there is no *Anopheles* restricted to the north or the south, the hills or the plains, the coast or the Ghor.

But if attention is devoted to oecology the grouping of species becomes clear. *A. hyrcanus* and *A. algeriensis* are characteristic of large areas of stagnant water. They are extremely abundant in the great marsh at Beisan, among the masses of papyrus (*Cyperus papyrus*) at Huleh, in the numerous coastal marshes (in which Barraud found *A. mauritanicus* associated with them) and in similar places throughout the country. The larvae of *A. hyrcanus* can generally be found in beds of *Typha* and coarse grasses, especially where the feet of cows, buffalos or wild swine have made holes in the black slime and afforded shelter from small fish. With them larvae of *A. algeriensis* are often associated, but when any distinction between the breeding places of these species can be made, it is found that *A. hyrcanus* breeds in the absolutely stagnant parts of a marsh, and *A. algeriensis* in the parts in which there is some slight current.

Occasionally *A. hyrcanus* and *A. algeriensis* are found breeding in small streams, but only when the current is very sluggish and the bed overgrown with vegetation. When they occur in such places as this one may find them associated with *A. elutus* and *A. sergenti*, two species which are rare or non-existent in the middle of great marshes, but common enough in the little affluents which conduct water from springs to the marshes, and in the effluents which carry off water from the marshes to the gardens and fields. It is not to be understood that *A. elutus* and *A. sergenti* require that their water should be flowing, for one frequently finds them breeding in perfectly stagnant pools in a wadi bed which is drying up, or in hoof-marks by the side of a small ditch. What they require apparently is that their breeding place should be part of a small rather than a large area of water, and that it should contain vegetation; in such situations they are common enough throughout Palestine. A rather unusual breeding place of *A. sergenti* was found by Annandale (Edwards, 1913), and we have repeated his discovery. He "found the larvae in small pools and springs among stones at the edge of the Lake (of Tiberias)." The larvae are often under the stones and not easily found. Plate xxviii shows such a site; no one would expect to find *Anopheline* larvae in such a place.

In small ditches which are flowing fairly actively one may find *A. sergenti* (and more rarely *A. elutus*) associated with *A. superpictus*; when the flow is rapid and not obstructed by grass or reeds, one expects *A. superpictus* and no other *Anopheles*. Its habits are well known, and it is hardly necessary to say that it may be found clinging to stones in eddies and backwaters of mountain torrents. It was in such places that I found it at Amman, Transjordan, in country quite unsuited to any other *Anopheles*; but a violent current is not necessary to it, for it bred also at Amman among green slimy algae in stagnant pools in the flood channel of the stream. In the Wadi Kelt Mr. Mieldazis discovered it breeding quite out of sight in the cavities made by boulders in the stream bed (Plate xxix). At Jericho it breeds freely in a small but rapid leak from a concrete mill-dam, the water of which is seldom more than a span wide and a centimetre deep, and in quite stagnant pools in a carelessly irrigated banana-garden. Near Kinereth Dr. Kligler found its larvae in patches of aquatic *Ranunculus* growing on a shallow in the River Jordan.

2. Association of the Species.

The seasons of greatest abundance of these species differ, as we shall see later, but occasionally one may have the good fortune to find all the species in one day and to trace the effect of environment upon them. In early September I walked down from the springs at the foot of the hills west of Lake Huleh, and found *A. superpictus* breeding in the springs and the swiftly running streams which issue from them. A little further down the current was sluggish and weedy; there I found *A. sergenti* and *A. clutus*. In a few hundred yards the streams entered the great marsh itself, and here the only species found was *A. hyrcanus*; doubtless in winter or spring one would have found *A. algeriensis* also. A few experiences like this make one see that the rural fresh water breeders consist of five species (excluding two rare species, *A. mauritanus* and *pharoensis*) and that these five species can be divided into three fairly clear groups: *A. hyrcanus* and *algeriensis* in large marshes, *A. clutus* and *sergenti* in small marshy spots and stagnant or slowly flowing streams, and *A. superpictus* in streams, and more rarely in still water.

There remain two species, which are generally found by themselves. *A. multicolor* breeds in salt water, for instance in small saline puddles in the salt-works at Athlit, and also in the Jordan Valley (Barraud). Dr. Kligler has found it near Naaneh in Wadi Surar, breeding in a small hole which had been made for watering sheep, the water of which tasted salt. *A. bifurcatus* breeds more often than anywhere else in wells and cisterns under and close to houses; it breeds also in smaller bodies of water, in fountains and holy water receptacles in churches, in buckets and crocks in houses, and in rock tombs containing rain water. It is therefore in the main an urban species, in contrast to all the other *Anopheles* of the country. If it were exclusively urban its control would be difficult but not impossible, but the problem is complicated because it is also a rural species. I have records of it breeding in springs in caves, and twice in open water. The first occasion on which it was found in open water was in the Birket Ramadan, a great coastal marsh about 15 miles north of Jaffa, on 16th November; here it was associated with *A. hyrcanus* in great numbers, and only two larvae of *A. bifurcatus* were found. The second locality is the Wadi Kabala, between Jerusalem and Latron; this is a very sluggish perennial stream, fed by springs, and we have found *A. bifurcatus* larvae in it on several occasions between March and June, associated with those of *Theobaldia longiareolata*, *Culex pipiens*, *C. mimeticus*, *C. hortensis*, and *C. apicalis*. Barraud records that he found *A. bifurcatus* breeding in a very similar situation at Beirut (Syria). Mr. Wilson observed the species breeding in winter in an "ornamental" concrete tank in a garden in Jerusalem (November); the larvae of *A. bifurcatus* kept to the south side, against the wall of the tank and so were sheltered from sunlight, the larvae of *Culex* and *Theobaldia* kept to the north side where they were exposed to the sun. It is not at first sight easy to see what is the common characteristic of these breeding places of *A. bifurcatus*, and why the species is not widely distributed in large marshes and slow streams, if it can exist in Birket Ramadan and Wadi Kabala. Probably the limiting factor is one of temperature. *A. bifurcatus* is a northern species, attaining the southern limit of its distribution in Palestine. I suggest that it normally breeds in cold waters, such as those of cisterns, caves, etc., and that it can only invade the open waters in winter, as in the case of Birket Ramadan, or when they are very heavily shaded, as in Wadi Kabala; this would account for its choosing the shady side of a tank. Our knowledge of temperature conditions in open and covered waters is very inadequate. For the benefit of future workers I put it on record that the temperature of a cistern varies 1-2° C. daily in summer, and that we have never had a reading above 21° C. in a cistern in summer though we have taken several hundred readings. I have taken very few readings in open waters, but shallows in the marsh at Beisan reach 35-38° C. in the middle of a summer's day.

The grouping of the various *Anopheles* with each other and with the Culicines is made clear in the following table, which is compiled from all our breeding records; unfortunately the number of lots bred is insufficient to enable me to treat the matter statistically.

Species.	Common Associates.	Rare Associates.	Occurs alone.
<i>A. elutus</i>	<i>A. sergenti</i> <i>C. perexiguus</i>	<i>C. pipiens</i> <i>A. superpictus</i>	Commonly
<i>A. bifurcatus</i>	<i>C. pipiens</i> <i>T. longiareolata</i> (urban)	<i>C. apicalis</i> <i>C. hortensis</i> <i>C. laticinctus</i> <i>C. mimeticus</i> <i>A. hyrcanus</i> (rural)	Commonly
<i>A. hyrcanus</i>	<i>A. algeriensis</i>	<i>A. bifurcatus</i> <i>A. superpictus</i> <i>A. sergenti</i> <i>C. perexiguus</i> <i>O. caspius</i> <i>O. detritus</i> <i>T. annulata</i> <i>A. hyrcanus</i>	Never
<i>A. superpictus</i>	<i>C. mimeticus</i> (rapid torrents) <i>A. sergenti</i> <i>C. perexiguus</i> (slow and stagnant)	<i>A. elutus</i> <i>U. unguiculata</i> (slow and stagnant)	Commonly
<i>A. sergenti</i>	<i>A. superpictus</i> <i>A. elutus</i> <i>C. perexiguus</i> <i>U. unguiculata</i>	<i>A. hyrcanus</i> <i>A. algeriensis</i> <i>C. pipiens</i> <i>C. hortensis</i> <i>C. tipuliformis</i> <i>C. tritaeniorhynchus</i> <i>O. caspius</i> <i>A. sergenti</i> <i>C. pipiens</i> <i>C. hortensis</i> <i>C. tipuliformis</i> <i>C. perexiguus</i> <i>O. detritus</i> <i>T. annulata</i>	Rarely
<i>A. algeriensis</i>	<i>A. hyrcanus</i>		Commonly

We are entirely ignorant of the cause of these associations, but it is of the greatest importance to study them, because if one could discover what factor prevents a certain *Anopheles* from breeding in a certain place, the discovery might lead on to a new and potent form of natural control.

MacGregor has shown that hydrogen ion concentration is one of the factors which limits the breeding of *A. plumbeus* to rot-holes in trees, and Atkins has published a useful review of hydrogen ion concentration as a factor in the geographical distribution of fresh-water invertebrata. He calls attention to the fact that *A. maculipennis* and *bifurcatus* breed in alkaline waters. One of his general conclusions is perhaps open to question; he suggests that Pusa (India) and Lower Egypt are free from malaria because their waters are alkaline. This conclusion seems a little premature; one wants such a mass of information not yet available relating to the pH of countries which are or are not malarious. Lower Egypt is, moreover, peculiarly situated; cut off from the African Anophelines by the deserts to the south and west, and from the Palaearctic species by the Sinai desert, possibly the cause of its relative freedom from malaria is zoogeographical. These problems are of great complexity, because they necessitate the study of each individual species of *Anopheles* in as many places as possible. In Palestine we have not yet reached any conclusions, but I feel confident that the few facts I now detail will be of value later on. For very many of them I am indebted to the energy of Dr. Carley and Mr. Mieldazis.

1. Palestine in general is a cretaceous country and its waters are alkaline. Springs issuing from the ground are nearly neutral, because they contain a relatively high tension of CO_2 in combination; many of them read about 7.4-7.6; after they have run a few hundred yards the CO_2 tension becomes more nearly equal to that of the air and the pH reading rises, and rapidly becomes constant at or about 8.0-8.4. This is true of nearly every stream in the country. The presence of a mass of water-weeds brings the reading up, during daylight, because the weed is obtaining carbon dioxide by breaking up bicarbonates in the water. The carbonates which result are more alkaline than the bicarbonates which preceded them, and the pH reading rises in the middle of a mass of weeds. This and the rise in alkalinity as a stream is followed from its source is illustrated by the following readings taken in the Ain es Sadia, near Haifa, and in the brook that runs down from it to the Kishon. All parts of the spring head were at 7.6, except a patch of green algae in which the reading was 8.0. A hundred yards below the spring the reading was 7.6; 150 yards, 8.0; 250 yards, 8.2; 600 yards, 8.2; 800 yards, 8.2 plus; here the brook joined the Kishon, already a wide sluggish river, reading 8.2-8.4.

2. The only marked exception which we have discovered is the water of Nablus. A number of springs bubble out in the town itself, and the readings at the spring head are 7.0-7.35; this reading rises, but in no case have I obtained a reading above 7.5 in the town or gardens; about 1 kilometre west of the town below the last garden the reading rises to 8.3. Be the cause what it may—and it is an interesting geological problem, for Nablus is on the limestone—the waters of this place are unique in Palestine (so far as our knowledge goes) because they are only slightly more alkaline than neutral, and the town is unique because it is quite free from malaria, in spite of the abundance of water in it and in the gardens around it. This absence of malaria cannot be attributed to the vigilance of the Department of Health, because anti-malarial measures have never been required. The spleen-rate is nil (170 boys examined), but the disease is common in the surrounding villages, even as near as 23 miles away. One cannot, until many more waters have been studied, say that the approximate neutrality of the water causes the absence of *Anopheles*, but the results are extremely suggestive.

3. The following species have been found in waters the pH of which was as indicated:—

A. superpictus: Tel es Sharieh, Beersheba, 8.3; Wadi Ghuzze, in patches of *Chara foetida*, 8.0-8.8; Ain es Sultan, Jericho, 8.0.

A. elutus: Wadi Ghuzze, in patches of *Chara foetida*, 8.0-8.8; Wadi Barideh, near Jaffa, 7.4-7.6; Wadi in plain S. of Nazareth, 8.0-8.2.

A. hyrcanus: Wadi S. of Nazareth (as above), 8.0-8.2.

A. sergenti: Wadi S. of Jenin, running from Kabatieh, 8.0; Wadi S. of Nazareth, 8.0-8.2.

A. algeriensis: Wadi S. of Jenin (as above), 8.0.

A. multicolor: Athlit salt pan, 8.2 plus (water very salt).

It will be seen that very few records are available. So far as they go they show that six of our *Anophelines* will live in the alkaline water of Palestine; they do not show that this is the optimum, or that no other water would suit these species.

4. All readings have been taken by indicators; the standards used are Sørensen's phosphate mixtures (pH 5.2-8.0) and Palitzsch's borax-boric-acid mixtures (pH 7.0-9.2). No corrections have been made for "salt error" or for temperature.

The salinity of the waters, and in particular the proportions of different salts, would perhaps throw light on the problem, but I have not studied the matter.

Two things have helped me in my oecological studies. The first is the identification of the larvae of the Palestinian *Anopheles*, which is dealt with below (page 309), for

observations on the various species and their environment were impossible before we could identify the larvae. One had to tour with a number of wide-mouth bottles, and the larvae and pupae were frequently so shaken that they all died; now, with small tubes of spirit one can collect ten times the number of samples one could before, note their exact locality and habitat, and identify them with certainty at one's leisure. The second thing that has assisted me is that I have been left alone to work in my own way; it has therefore been unnecessary to be continually racing about Palestine, and I have been able to select places and study them at leisure. I am quite certain that more has resulted from my staying repeatedly in Beisan than could have resulted from more "comprehensive" surveys.

3. Seasonal Occurrence.

The association of various species is complicated by the fact that they have various seasons of emergence. For instance *A. sergenti* and *Uranotaenia unguiculata* are found in the same type of water, at the same time; *A. algeriensis* quite often shares their habitat, but it has a very different season of emergence.

The time of emergence of some species is very sharply defined. This was brought clearly to our notice in the autumn of 1922 by *A. sergenti*. Annandale records of this species that "between October 2nd and October 20th I saw only one Anopheline mosquito at Tiberias. On October 16th the first rain of the season fell, and on the morning of the 20th I noticed numerous Anophelines of both sexes flying into my room through the window. The same species continued to be common in the house until I left Tiberias on Oct. 27th" (Edwards, 1913). Barraud found a few in tents at Tabgha, on the Lake of Tiberias, 15th August, and had previously bred a few from pools along the Nazareth road at Haifa. The species was regarded as uncommon, and when I secured two larvae in June at Beisan I thought them a rarity. On 30th August we found adults of both sexes in houses in Tel esh Showk village, near Beisan; they were more abundant than *A. elutus* and *superpictus* with which they were associated. I was bitten by this species at Beit Jibrin (22nd Sept.) and could find no other species. Then I got larvae in Wadi Latron (4th Oct.) and predominantly at Shellal (20th Oct.); next we found the species more numerous than *A. elutus* at Nahalal and Shuneh (12th, 13th Nov.). I thought it very remarkable when I got adults and larvae at Jericho (13th, 15th Oct.), breeding in various places which had produced nothing but *A. superpictus* during the summer. In fact, *A. sergenti* is probably the commonest species in Palestine from September to November, the only possible exception being *A. elutus*. I was away on leave during the winter, but Dr. Carley and Mr. Theodor found this species common, and often predominant through December and January, and on the 14th April I found *A. sergenti* and *hyrcanus* both breeding at El Maskereh, between Jericho and Fusail in the Jordan Valley. On the other hand, by 9th March 1923 *A. superpictus* was once again the only species found in Wadi Kelt and at Jericho; since that date we have once bred a single *A. sergenti* with about 50 *A. superpictus* from Ain es Sultan, Jericho (8th June). We have unfortunately no information as to the manner in which *A. sergenti* passes the summer; whether it continues to breed very rarely, as is suggested by the larva just mentioned and by the two larvae found in June at Beisan, or whether it actually aestivates, either as an egg or an adult.

A. algeriensis also has a well-defined season. In the Beisan marshes, which have been studied at all times of the year, it is the dominant species on the wing from January to March, and continues as an uncommon species from April to June or even July; from July till November adults are apparently absent. *A. hyrcanus*, on the other hand, is rare in February, becomes rapidly abundant in the spring and remains dominant through May and June; after that it becomes rarer, but is never entirely absent at any season of the year. Confirming this we have evidence, which is less complete, but shows that in the great coastal marshes (Nahr ez Zerqa, Kishon, Namein) *A. algeriensis* is dominant in winter and spring, and *A. hyrcanus* in late spring and early summer;

the season of *A. algeriensis* in these marshes is prolonged later into the summer than at Beisan, perhaps because the mean temperatures month by month are lower in the coastal plain than in the Jordan Valley. Be the cause what it may, Mr. Theodor found *A. algeriensis* adults and larvae still quite common at Benjamina early in June and at the end of June.

There is little doubt that *A. superpictus* hibernates as an adult even under the mild winter conditions of the Jordan Valley, though I have never found the insect doing so. On 24th March larvae were not found at Ain es Sultan, Jericho. From 9th April to 21st September active breeding has been found at every visit; no breeding of this species was found during the late autumn and winter. The same seasonal incidence has been observed in Wadi Kelt (Plate xxix) at about sea-level, but here our information is less complete, as the place is not very accessible.

The seasonal prevalence of *A. elutus* is similar to that of *A. superpictus*. At the end of March and in early April one finds larvae but no adults in the coastal zone (Nahr ez Zerqa, Akka); by the middle of April adults are common, and they continue so until the end of November, at which date females can be taken in great numbers in stables. Clearly therefore the species hibernates in Palestine, just as *A. maculipennis* does elsewhere.

A. bifurcatus does not hibernate or aestivate in Palestine; as it breeds in wells, caves and underground cisterns, its environment is less exposed to seasonal change than that of the other species. Barraud has recorded that larvae taken on 18th November took two months to pupate; this, however, was a case of slow development, not true hibernation. Under natural conditions in Jerusalem all stages may be obtained at all times of year, provided only that the attentions of the oiling gang can be avoided.

The hibernation and aestivation of the Palestine *Anopheles* is a subject to which future workers should devote attention; but it seems clear that *A. sergenti* is abroad in autumn; *A. algeriensis* in winter and spring; and *A. superpictus*, *A. elutus*, and *A. hyrcanus* in summer and autumn (the first two at any rate hibernating as adults); *A. bifurcatus* probably breeds at all seasons. As to *A. multicolor* I have no information.

I have searched for evidence of a succession of broods, clearly separated in time from one another, but I have found none in the case of any of our species of *Anopheles*. So far as I know breeding is continuous and all stages may be found together throughout that part of the year during which the particular species is active. For instance, one can always find *A. superpictus* (larvae of several sizes and pupae) at Ain es Sultan, Jericho, throughout the summer, and I have found *A. bifurcatus* breeding in Wadi Kabala every time I have visited the place.

4. The Rural Species in Relation to Man.

What I have so far recorded relates to the *Anopheles* themselves, in their natural haunts; it remains to discuss them in relation to man. We may exclude from consideration the rare species *A. pharoensis* and *mauritanus* (page 51) and confine our attention to the remaining seven species, all of which are common in some part of the country at the right season. I have seen all of them bite man under natural conditions, but they do not all seek him. At Beisan in the summer of 1922 a party of archaeologists pitched their camp, not perhaps very wisely, on the leeward edge of a small marsh of about an acre in extent. One could always take adults of *A. hyrcanus*, and occasionally *A. algeriensis*, in this marsh at dusk, within 20 yards of the tents, and the larvae of *A. hyrcanus* were abundant in the marsh. No adults of this species or *A. algeriensis* were ever taken in the tents, though repeated search was made in June, July and August. On the other hand, one could find one or more *A. elutus* in each tent every morning; the larvae of *A. elutus* were never found in the little marsh, but I suspect in the light of later knowledge that the species was breeding in a weedy

irrigation channel which ran from the marsh to a patch of tomatos. If this was the case, then a few *A. elutus* were searching out the camp from a distance of a hundred yards and a large number of *A. hyrcanus* were refraining from entering it from a distance of twenty yards, though they bit with avidity if one sat in the marsh. Mr. Theodor has made very similar observations this summer at Benjamina; in the swamp of the Nahr ez Zerqa the predominant larvae and adults are *A. algeriensis* and *hyrcanus*; in the houses of the Jewish Colony he finds nothing but *A. elutus* and *multicolor*.

These are by no means isolated observations; I have not a single record of the occurrence of *A. hyrcanus* or *A. algeriensis* in a tent or a house, but *A. elutus*, *sergenti*, *superpictus* and *multicolor* all enter houses and attack man and then rest in the house if a suitable spot can be found. This division of our rural species into two groups is very sharp.

If we suppose, and we can scarcely do otherwise, that *A. hyrcanus* and *A. algeriensis* are of very small importance as carriers of malaria, then it becomes clear that *A. elutus* is a major carrier. Cropper recorded the presence of "*A. maculipennis*" (by which no doubt he meant *A. elutus*) in houses on the banks of the River Belus (Namein River, close to Akka) in such numbers that people had to sleep in a smudge of smoke. Throughout late spring and early summer it is abundant; in some parts of the coastal plain, for instance in the colonies at Zichron Yakob and Benjamina, it occurs in houses in company with *A. multicolor*. In other places it occurs alone, and then its association with outbreaks of malaria is very clear. The Malaria Research Unit keeps very careful statistics relating to malaria in all the Jewish colonies, and I am indebted to Dr. Kligler for calling my attention to two colonies in which no *Anopheles* except *A. elutus* has been found. The colonies are Ain Ganim and Khedeira, and in them the malaria epidemic is worst in July and August, as the following figures show.

Table showing incidence at Khedeira and Ain Ganim of malaria, monthly for 1922, per hundred of population.

Place.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Khedeira ..	?	1.8	4.3	2.0	2.0	2.5	9.0	9.0	4.0	2.7	3.0	1.0
Khedeira (working men) ..	?	?	?	0.0	4.7	8.0	15.0	10.0	8.0	6.5	3.3	4.0
Ain Ganim ..	?	?	?	?	0.75	2.0	4.7	4.4	3.3	3.3	1.1	2.0

One wonders whether *A. elutus* is predominantly the carrier of benign tertian malaria, which has its greatest incidence in Palestine in August (fig. 1). In all the other colonies other species of *Anopheles* are found as well, and in them the malaria is commonest in autumn.

A. sergenti is, as we have seen, perhaps the commonest rural species during its short season of emergence: it is most common from September to November, but a few adults can be found in August. This period of activity corresponds with the season of incidence of malignant tertian (subtropical) malaria. The graph in figure 1 shows the numbers of malignant tertian, benign tertian, and quartan cases diagnosed in all the laboratories of Palestine in 1922. It is based on 30,000 films examined. I am indebted to Dr. G. Stuart for it. The coincidence between the season of malignant tertian malaria and that of *A. sergenti* is remarkable, and it appears probable, but by no means proved, the *A. sergenti* is the principal carrier of malignant tertian malaria in Palestine. It is unfortunate that I have never found a place in which *A. sergenti* occurs without *A. elutus*. If such a place could be found it would be extremely valuable to study its malarial incidence month by month.

The case against *A. superpictus* is proved in many parts of the Near and Middle East, notably by Wenyon and his helpers in Macedonia. In Palestine I have never found *A. superpictus* unmixed with other species of the genus, except in the Wadi

Kelt and at Jericho, in summer, and I have not been able to incriminate it definitely. The Wadi Kelt is almost unpopulated, and at Jericho the problem is complicated by the presence of *A. sergenti* in winter. One cannot therefore attribute the malaria which is prevalent (Boys' school, spleen rate 17 per cent. approx., parasite rate 27 per cent. approx., January 1921, only 39 boys examined) to either species, in the absence of further research. In the Wadi Zerqa, in Transjordan, malaria is exceptionally severe; at Amman itself it is common, but further down the valley, at the Circassian villages of Sukhna and Zerqa most of the children had palpable spleens. All this malaria is probably due solely to *A. superpictus*, which breeds in great numbers in the stony bed of the Wadi. I found no other species in August and September, and I found no places which seemed to be suitable to other species.

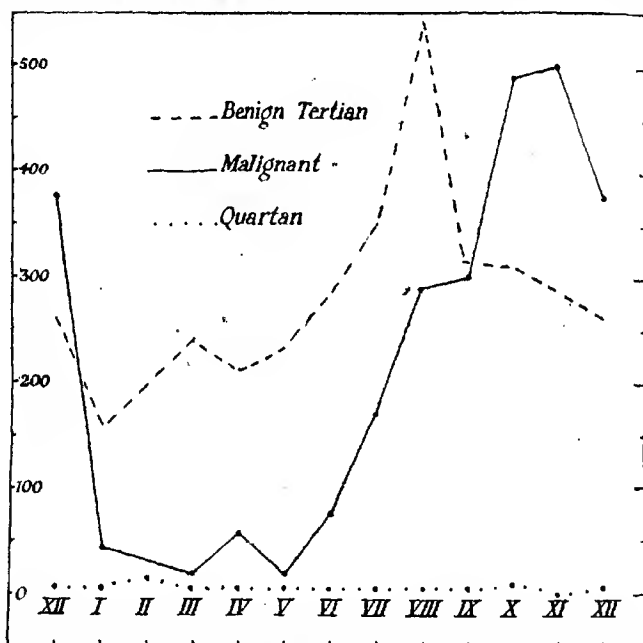


Fig. 1. Graph showing numbers of cases of benign tertian, malignant tertian, and quartan malaria diagnosed in Palestine laboratories month by month in 1922.

A. multicolor is probably of less importance than *A. elutus* and *sergenti*. I have never found it in numbers, but it is widely distributed in the coastal zone. At Athlit it breeds in salt marshes and is said to cause a very high incidence of malaria, but it is associated with *A. elutus*, which breeds in fresh pools and creeks in the immediate vicinity, and which is also found in the houses. I believe that this species has a greater range of flight than our other species, as I have several times found isolated individuals in houses at a great distance from what was presumed to be their breeding place. On 1st June Theodor found that the dominant species in the marshes of the Nahr ez Zerqa were *A. algeriensis* and *A. hyrcanus*; *A. elutus* was also common, though no larvae were found. In the settlement of Zichron Yakob, about two kilometres from the marsh and several hundred feet above it, he found nothing but *A. multicolor*. Their breeding place was not located, but if they were not bred in the marsh they must have come from even further away near the coast.

5. The Domestic Species.

The urban *Anopheles bifurcatus* is in a class by itself. Its commonest breeding-place, as we have seen, is the domestic well and cistern. In many houses the mouth of the cistern is immediately outside the door, or even in the house itself. These domestic cisterns are extremely numerous in many of the towns and villages in all parts of the country; in Jerusalem alone some 7,000 are registered. Plate xxx shows a type of well which is fairly common; it is almost impossible to render such a structure mosquito-proof. On the other hand, many places are supplied by a spring, often at some distance from the village, and in these there are no cisterns or very few. In the plains, the village water-supply often comes from a single well or spring outside the village; in the hills most of the villages depend entirely on rain-water stored under the houses, and therefore suffer severely from malaria. Many of the Jewish colonies are provided with a piped water-supply. The *A. bifurcatus* which breeds in the cistern is a good carrier of malaria; of that there is no doubt at all, because epidemics of malaria occur in places from which other *Anopheles* are completely absent. Of this the classical example is Jerusalem itself, a city lying on the very water-shed of the country, miles from any running water or swamp, rainless or nearly so for half the year. In this city (Sept.-Dec. 1912) Mühlens found actual parasites in 26.1 per cent. of 7,921 people examined.

In greater detail his parasite rates were as follows: Jews, 40.5 per cent; Moslems, 31.1 per cent.; Native Christians, 16.4 per cent.; Europeans, 7.2 per cent; children of all faiths under 14 years, 27.3 per cent.; persons over 14 years, 23.1 per cent.

During the time of General Allenby's occupation of Jerusalem (Dec. 1917) it is probable that malaria was even more prevalent, because the population was almost starving, without fuel and insufficiently clothed. Measures were soon taken to make a census of all wells, cisterns and other breeding places, and to deal with them by methods which are discussed below (page 304), and these measures have continued in force ever since. The result is that the British Administration has nearly but not quite stamped out *Anopheles bifurcatus*, and with it malaria in Jerusalem. The certified deaths from malaria have fallen steadily since 1918: figures year by year are 1918, 113; 1919, 35; 1920, 30; 1921, 17; 1922, 5. How many of the five people who died in 1922 had actually been infected in the city is not known; it is to be remembered that Jerusalem is only a long day's walk from the coastal swamps in one direction, and the Jordan Valley in the other.

The malaria of Haifa town was almost certainly urban in origin, and due to *A. bifurcatus*, though many authorities have blamed the Kishon marshes, distant about a mile and a half from the nearest end of the town. It is at any rate certain that in 1918 *A. bifurcatus* was extremely abundant (Barraud), and that now it is very rare; also that antimalarial work has been almost confined to wells and cisterns, and that the Kishon marshes have not been dealt with; also that the malaria in the town is greatly reduced. The conclusion drawn is that here again the malaria is urban in origin. I do not, of course, say that the Kishon marshes are a safe place to live in, but that the harm they do to the town of Haifa is slight.

The story of Akka is similar. Until the matter was studied carefully it was believed that the malaria came from *Anopheles* breeding in various marshes outside the town, and no doubt this is the case to some extent, but I have twice been able to find *A. bifurcatus* breeding in wells and cisterns inside the walls of the town. In the hill villages, and many of the villages of the coastal plain, conditions are the same, though in many cases the truth is obscured because the inhabitants own land or work in harvest-time at a considerable distance from the village; this often necessitates their living in their fields in reed huts for several days at a time, and no doubt results in some of them contracting malaria. It is unfortunately true that Palestinian Medical Officers of Health tend to attribute all the malaria in the hill villages to these semi-nomadic habits, and to conclude that nothing can be done to eradicate the disease; one can, however, very

often demonstrate *A. bifurcatus* in the village wells and cisterns. The following examples are typical of what is going on in all parts of the country. At Mekkar, near Akka, Dr. Carley and I were told (Nov. 1922) that there had recently been an epidemic of malaria, attributed to the fact that the men had been away in the plain cutting reeds; but we found an enlarged spleen in a suckling baby, and we found female *A. bifurcatus* sitting inside a well-head in the village. At Bassa, north-east of Akka, malaria is extremely prevalent; Dr. Carley and Mr. Mieldazis found that 15 out of 21 persons examined had enlarged spleens, and that the parasite rate was about 35 per cent. (seven positive films out of 20 examined, March). All this malaria was quite wrongly attributed to summer reed-cutting and to a reservoir three miles away; it was much more probably caused by the cisterns in the village. At Shaab the same investigators found a spleen rate of 25 per cent. in the school-boys, and *A. bifurcatus* in the wells; at Damun, 14 grossly enlarged spleens in 20 boys, attributed by the local doctor to a marshy place 5 miles away. One might multiply instances to an indefinite extent, all leading to the conclusion that it is impossible to exaggerate the importance of *A. bifurcatus*. It is so widely distributed, so closely associated with man, so abundant at all seasons if wells and cisterns are not treated, that I have no hesitation in saying that it far surpasses the rural species in importance; its destruction is the greatest sanitary problem with which Palestine is faced.

6. Results of Dissection.

It remains for someone else to test these conclusions by dissection of large numbers of wild-caught females, and I can only regret that the number of dissections I have performed is quite insufficient. Including the insects examined by Dr. Carley and by Mr. Theodor, the following number of wild-caught females have been dissected without our finding oocysts or sporozoites once: *A. hyrcanus* (Beisan and Nahr ez Zerqa marshes), 120; *A. elutus* (bedrooms and stables, Shuneh, June), 114; *A. multicolor* (bedrooms and stables, Shuneh, June), 47.

From all that has been said, the conclusion is that the most dangerous of all the *Anopheles* is *A. bifurcatus*, because it is generally so closely associated with man; that *A. elutus*, *A. sergenti*, *A. superpictus* and *A. multicolor* are all dangerous species, because they are known to enter houses, and because they are (at any rate the first three) closely associated with outbreaks of malaria in Palestine; that *A. algeriensis* and *A. hyrcanus* are of little importance because they remain strictly in the marshes in which they breed.

7. Artificial Control.

It is not my purpose to describe at length the manner in which well-known measures for the control of *Anopheles* have been applied in Palestine, but rather to draw attention to some of our peculiar problems, and of the methods which have been applied locally to deal with them. These methods fall into two clearly defined groups; the urban methods directed against *Anopheles bifurcatus*, and incidentally *Culex*, *Theobaldia* and *Stegomyia* (see Part III), and the rural methods, directed against *A. elutus*, *sergenti*, *superpictus*, *multicolor*, *hyrcanus*, and *algeriensis*, to name them in descending order of importance.

Against *A. bifurcatus* in Jerusalem the military sanitarians achieved great success along lines which had already been foreseen by Cropper and Masterman. They catalogued the wells and cisterns, and arranged to oil each with paraffin 4 parts and crude oil 1 part, every fortnight. The obvious criticisms of this method are that it depends for its success even in Jerusalem on the unceasing vigilance of a European

inspector, and of the Principal Medical Officer; the whole scheme rests on very unstable foundations, the men who compose the oiling gang; furthermore the method is expensive and the expense is recurrent.*

An attempt has been made to induce the population to instal pumps, and to make their wells and cisterns mosquito-proof; the inducement to do this is that if a cistern is properly "proofed" it is impossible for the Government to oil it, and render the water unpleasant to drink. In Jerusalem about 1,500 pumps have been installed in 1921-1922, but over 30,000 breeding places (6,100 wells, 4,100 cisterns, 20,600 other places) remain not properly closed, and are still oiled every fortnight. In May 1918 a piped water-supply was installed in parts of Jerusalem, and this has been extended and is still in process of extension. At present the supply is about 2½ gallons per head of population per day, so that the installation has not brought about the closing of many cisterns.

Schemes for a properly piped supply of water to many other towns and villages are in active preparation, and some of them are actually working. They will undoubtedly tend to reduce *A. bifurcatus* and malaria, because they will result in the permanent closing of many cisterns. One must not be too sanguine about these schemes, bearing in mind the fact that *A. bifurcatus* breeds frequently in buckets and barrels in the back-yards of houses, and that this sort of breeding and the measures necessary to limit it are recurrent. On the other hand, it is an undoubted fact that *A. bifurcatus* is much more easily banished than *Culex*, *Theobaldia* or *Stegomyia*.

A similar policy of fortnightly oiling wells and cisterns, and of closing them when possible, has been pursued in every village and town in Palestine; the Department of Health has 55,000 permanent breeding places (wells, cisterns, etc.) registered in the towns, and 25,000 in the villages. In spite of the difficulties, the work in all parts of Palestine has met with very great success. We do not know what the spleen rates and parasite rates were in these places before the British Occupation and one cannot therefore quote statistics; but we do know that the villagers testify unanimously in favour of the antimalarial work, that they no longer oppose the activities of the Antimalarial Sanitary Sub-inspectors; and if oiling is not performed regularly they come in to the Governor's office and petition him to put the matter right. This is very remarkable, for one must remember that in the villages water is drawn in a bucket, and tastes unpleasantly of paraffin for several days after the oil has been applied.

I have, I think, said enough to show that the problem of controlling urban malaria, though simple in the sense that only one *Anopheles* is concerned, is gigantic. The rural problems are much larger and more interesting because the terrain and climate are so varied, and because one is concerned with several species of *Anopheles*. Some of the less serious problems are caused by the abundance of winter rains. Caves and rock tombs fill with water and form prolific breeding places of *Theobaldia*, *Culex* and rarely *A. bifurcatus*; but the winter rains produce graver consequences than this. I have already referred to the ridges of rock along the coast south of Haifa, and to the fact that they impound rain-water which would otherwise run away. The swamps formed in this way may be six feet deep and last until July, following a wet winter, and in this case they will cause an outbreak of malaria in any village which is near; or they may never be two feet deep, and dry up in April, in which case they are harmless. The malaria at Tantura is caused in this way. The problem here is not one of keeping the area concerned absolutely dry in winter, but of preventing it remaining wet until summer, and I have suggested that the cheapest way to do this would be by the installation of windmill pumps; from the

* In 1922 the Department of Health employed 36 Antimalarial Sub-inspectors, in the whole of Palestine, paid at £E 72-96 plus subsistence allowances when out on tour, and a number of oilers, paid by Municipalities, were also constantly at work. They distributed 66,000 kilogrammes of crude oil and paraffin, which cost £E 960. I understand that Solar Oil is to be used in future, and that this will effect a great economy.

engineer's point of view the scheme is well-spoken of, but it has not yet been carried into effect. Blasting a channel through the rock would be ineffective, because the channel would rapidly fill with fine sand. The Marj Sanour is another serious problem after wet winters: it lies between Nablus and Jenin, and is a cup-shaped hollow in the hills with no outlet. The winter of 1919-1920 was exceptionally wet, and the Marj Sanour filled to a depth of about six feet, with an area of about 8 square kilometres, and parts remained wet till July. This produced a very grave outbreak of malaria in the eight surrounding villages; Sanour, with an estimated population of 1,000-1,200 people, had 400 deaths in two years; Meithalun in one autumn lost 80 of its inhabitants, not more than 800 in number. This was the greatest epidemic of fifty years. The problem of the Marj Sanour is peculiarly difficult; it cannot be drained because the lowest pass leading into it is 54 feet above the bottom of the swampy area; for the same reason it would be extremely expensive to pump it dry. The inhabitants point to a depression in the plain and say that it is the mouth of an ancient tunnel, and that in days of long ago it functioned as a drain. Without feeling very much confidence in this tunnel, but hoping to open a crack in the lime-stone which lies below the impervious red soil of the plain, Mr. Mieldazis had this place excavated last winter and exploded 50 pounds of dynamite in it. The result at first was encouraging, but it appears that the crater made by the explosion has already begun to fill up, as it was not retented. Other cup-shaped hollows exist among the hills, but none of them are completely land-locked except the Marj Sanour. One of the largest is the Sahel el Buttauf, N.E. of Nazareth; it is very flat, and becomes a quagmire, even a shallow lake in winter, because its drainage to the Mediterranean is insufficient to dry it before March or April.

Other problems which have to be faced depend partly on perennial springs and partly on winter rain. Many of the valleys which run westwards from the hill country carry off winter rain but are fed also by springs at the point where they leave the limestone and enter the coastal plain. It follows that there is a nearly continuous string of wet wadi-beds and malarious villages along the foot of the hills, throughout the whole length of the country; good examples are Beit Jibrin and Tel es Safi, W. of Hebron; Shuneh, near the head of the Nahr ez Zerqa; and Kabri, Nahr and other villages in Wadi Kurn, N.E. of Akka; but many more might be quoted. These places present a problem which recurs every year, because any work which is done to clear and straighten the course of the Wadi in summer is destroyed by the winter torrents; work of this sort is done by the villagers themselves under supervision by the Department of Health.

I have already (p. 290) described the coastal dunes and the great marshes which lie behind them because all the little rivers are blocked. In spite of the richness of the soil and the abundance of water much of this area lies desolate, owing to the malaria. The land round Nahr Iskandaruneh and the Birket Ramadan is only inhabited by a few nomads; Wadi Rubin is as desolate, except in August when the birthday of the prophet draws thousands to camp round his tomb and become infected with malaria. The Wadi Auja is less of a menace, because its banks are steep and sharply cut through most of its course, but it and its tributaries cause a considerable amount of malaria among the Jews, Arabs and Germans who cultivate the surrounding land. The Kishon marshes and those of the Namein River do not, I believe, cause much malaria in the towns of Haifa and Akka (see above, page 303), but the cultivators who live in and close to them suffer severely. Each one of this string of coastal marshes is a large engineering problem, difficult because of the sand-dunes which fill in any drainage channel which is made, more difficult because the marshes lie within a very few metres of sea-level.

In certain places in the Jordan Valley a rather different problem arises. Many of the tributaries on the right bank between the Lake Tiberias and the Dead Sea arise from large perennial springs, which gush out at the foot of the cretaceous hills, at the margin of the alluvial plain. The water from these springs is used to irrigate small

gardens, and the system is so imperfect and wasteful that little swamps are produced in which *A. sergenti* breeds in autumn and winter, and *A. superpictus* in summer. I have already described such a breeding place at Jericho, when discussing *A. superpictus*. The trouble will become more formidable when the Jordan Valley is "developed." At Beisan the same difficulty obtrudes itself, but on a much larger scale; a number of large springs at the foot of Mount Gilboa discharge their water upon a shelf-like plain which is about 400 feet below sea-level and about 400-500 feet above the nearest part of the River Jordan. The results are a marsh, which breeds *A. hyrcanus* and *algeriensis*, and a number of primitive unorganised irrigation schemes in which *A. elutus* and *A. sergenti* breed. Local effort with very little expert direction has tackled the problem and very greatly reduced the malaria, and it remains to instal a system of irrigation, plans for which have been drawn up; this system allows for periodical drying of all irrigation ditches, and will also greatly enlarge the area under cultivation. Anti-mosquito work at Beisan should be directed against the small channels, that is to say the breeding places of *A. elutus* and *sergenti*, not against the much more conspicuous but relatively harmless marsh itself. In this case at any rate one can claim that the intensive study of species of *Anopheles* has "paid."

We have experimented with a flame-thrower, such as was used in the late war, in order to see whether it would provide an efficient or cheap method of destroying reeds and grass in irrigation channels. The experiment was carried out in October, at the driest part of the year, and was a failure; it proved impossible to burn the vegetation, and the apparatus was expensive to operate. I have also done some experiments in the laboratory to test the efficiency of trioxymethylene. I failed to kill *Culex* and *Stegomyia* larvae, using the powder at the rate of 3 gm. per sq. metre, though Roubaud states that 0.5 gm. is sufficient for *Culex*. When I exposed *A. hyrcanus* to 0.1 gm. per sq. metre two-thirds of the larvae were dead in 20 minutes, but one-third survived and eventually pupated. In this experiment the surface of the water was quite still. Had the experiment been performed in the open one may presume that any slight breeze would have caused the powdered drug to sink more quickly, and so reduced the proportion of larvae killed; on the other hand, the larvae might have been feeding more actively. I have performed no field experiments, but the Malaria Research Unit has the matter in hand.

8. Natural Control.

The financial resources of Palestine are small, and some of the malarial problems are very large. We have therefore studied the fish, not hoping to achieve complete control thereby, but expecting that they would assist us, and charge nothing for their assistance. I have already (1922) published the results of some dissections, from which I concluded that:—

- (1). *Mugil* is a vegetarian.
- (2). *Tilapia zillii* is a voracious, omnivorous species, probably of some value as a destroyer of mosquitos. Its usefulness is limited by the fact that it grows much too large to pursue the larvae in the shallows and among the weeds.
- (3). The species of *Cyprinodon* answer the purpose very well. They will eat anything which is in season, animal, vegetable, or mineral, creeping or swimming or even flying; they will support life and breed under a great variety of natural conditions. No one example out of 67 dissected contained recognizable portions of any mosquito, but many had recently eaten aquatic larvae and pupae.

Since that note was published the dissections have been discontinued, but we have made a large number of field observations, which have convinced me, and I think others also, that the species of *Cyprinodon* are of great value in the field. Again and again we have found *Cyprinodon* in a ditch or marsh, and noticed that the mosquito

larvae were confined to isolated footprints and other places which the fish could not reach. At other times we have found fish abundant and larvae, both Culicine and Anopheline, confined to masses of some filamentous green alga; one has learnt to search these patches, if larvae cannot be found in other places. I feel that the whole question of fish and their prey is one which can only be studied satisfactorily under natural conditions, and that experiments made indoors under conditions which are not in all respects natural can at best corroborate the results of field work. Some experiments made by Mr. A. Wilson in Jerusalem are open to this criticism, but they have certainly brought some interesting facts to light. Mr. Wilson finds that in captivity *Cyprinodon fasciatus* takes much of its food from the surface, and generally only seizes mosquito larvae when they wriggle. It has never been observed to eat pupae of any sort and cannot swallow the large larvae of *Theobaldia*. A single fish will eat 10-20 larvae of *A. bifurcatus* daily, if it is kept in a glass vessel in which other food is presumably scarce. *Cyprinodon* survived the winter of 1922-23 (which was a mild one) in open tanks in gardens in Jerusalem, and young fish were first seen at the beginning of May. They will survive a considerable degree of heat, for at Beisan I have noticed them crowding the shallows at midday when the temperature in the shallows was 37-40° C. (99-104° F.); this habit of entering small nooks and shallow places renders *Cyprinodon* all the more efficient as a destroyer of mosquito larvae. I have referred to these fish by their generic name alone because I find myself quite unable to distinguish the species. Most of the specimens submitted to Mr. Normand at the British Museum have been determined as *C. calaritanus*, *C. sophiae* and *C. fasciatus*. Several species often occur together, and I have no reason to suppose that they differ in their habits and ability to eat mosquito larvae. They are widely distributed in Palestine and have been artificially spread in the last year; in artificial tanks and fountains they appear to control the mosquitos completely. *Tilapia zillii* is not only less efficient than *Cyprinodon* by reason of its greater size, but is also a great enemy of the *Cyprinodon*, as Mr. Wilson has observed in a tank in Jerusalem. The family to which it belongs, the CICHLIDAE, is typically African, and has frequently been quoted as an example of the African element in the fauna of the Jordan Valley. It is interesting to note that *T. zillii* is by no means confined to that part of Palestine: it occurs in the Kishon and in the Auja near Jaffa, and doubtless in all the other coastal wadis and marshes.

Common eels (*Anguilla vulgaris*) are abundant in the coastal marshes and swamps. We have not used them as yet, but I kept one example 4 inches long in a tank (5 ft. × 2 ft. × 1 ft. deep) in a garden all last winter and it entirely prevented mosquito breeding; when the eel was removed breeding commenced at once. The eel possibly has a future as a controller of breeding in cisterns and other dark places unsuited to *Cyprinodon*.

The other enemies of mosquito larvae, for instance the DYTISCIDAE and dragonfly nymphs, have not been investigated, because it is difficult to see how one could propagate them or encourage their activities, even if one decided which species was most useful. I have observed the Libellulid *Orthetrum sabina*, Drury, hawking after sunset over the Kishon marshes, and as the species is common it probably consumes a number of mosquitos. Barraud (1923) records that he observed *Anax parthenope*, Selys (AESCHNIDAE) in August in the Kishon marshes "on several occasions flying after sunset, and even when it was almost dark." It will be remembered that Fraser has recorded that certain Indian Libellulids fly after sunset; he records four species which fly only at this time, and a fifth which is active "from dawn until long after dusk." All these species feed principally on adult mosquitos. Possibly the whole subject demands more attention than anyone has yet devoted to it.

No effort has been made to collect the predaceous water-bugs of Palestine. The following have found their way into my net: *Notonecta glauca*, F., Wadi Kabala, 29th March; *N. halophila*, Edw., Athlit, 14th November; *Naucoris maculatus*, F., Wadi Kelt, 9th April.

It appears to me that the efficacy of *Chara* against mosquito larvae has been exaggerated. Masses of it block a stream which runs down from Kabatieh and crosses the main road a few miles south of Jenin, but I have found larvae of *A. algeriensis* and *A. sergenti* actually in these masses on several occasions. In the Wadi Ghuzze, south of Gaza (Plate xvii), Dr. Carley and Mr. Mieldazis studied the question at a number of points. At six points they found *Anopheles elutus* and *superpictus* (and often *Culex* also) breeding in great masses of *Chara*; at two places the *Chara* was absent, and larvae were absent also, perhaps because they were exposed to predacious creatures. On the other hand, one or two of the pools in Wadi Kabala were choked with *Chara* and were free from mosquito breeding until the shepherds cut the *Chara* and then *Theobaldia* began to breed in them at once. The absence of larvae before the weeds were cut was remarkable, because *A. bifurcatus* and several Culicines were breeding in other pools in the wadi only a few yards away. It is, of course, possible that some species of the genus (and many exist) are toxic, or noxious, and others not.

9. Notes on the Species.

Throughout this paper I have used the synonymy of Edwards (1921). There are, therefore, some discrepancies between the names used by previous writers and those used in this paper. The principal are that *A. sergenti* is separated from *A. culicifacies*; that *A. elutus* is no longer referred to as a variety of *A. maculipennis*; that *A. palestinensis* is sunk in *A. superpictus*.

Anopheles hyrcanus, Pallas.

Seventy specimens, mostly females, from Beisan and Caesarea were examined critically, but not one var. *pseudopictus*, Grassi, was detected.

Anopheles superpictus, Grassi.

The egg is, I believe, undescribed. I obtained specimens in Wadi Kelt in May, but they were so broken by the time they reached Jerusalem that they cannot be described or figured. They were black in colour, 0.5 mm. long, 0.1 mm. deep, excluding the remnants of the fringe of air-cells.

Anopheles mauritanus, Grandpré.

Barraud speaks of this species as occurring regularly in the swamps of the Auja and Kishon. Possibly it has a short season; at any rate I have never taken it, and I know of no record other than Barraud's.

Anopheles pharoensis, Theo.

The only previous record of this species in Palestine was Barraud's, a single female taken at Tabgha on the Lake of Tiberias. I entirely failed to find it myself, but since I left Palestine Mr. Theodor has taken it at Birket Ata, near Khedaira (in a house with *A. elutus*, end of August), and at Shuneh on the Nahr ez Zerga, near Benjamina (one only, full of blood, in dormitory with *A. elutus* and *multicolor*).

Larvae of *Anopheles*.

I have recently (1923) described the differences between the fourth-stage larvae of *A. bifurcatus* and *algeriensis*, and between certain *Myzomyia* larvae; I hope that the Société entomologique d'Egypte will shortly publish a key which has given satisfactory results in Palestine. Mr. H. F. Carter has sent me larvae of *A. culicifacies* from Ceylon and Mr. Theodor and I have compared them with Palestine specimens of *A. sergenti*; we can find no distinction except in the extent of the dark markings on the vertex; though these are not very constant in either species, there is no overlapping between the short series of *A. culicifacies* and a large number of *A. sergenti*. The dark markings

of *A. culicifacies* are illustrated in fig. 2, those of *A. sergenti* in fig. 6 of my previous paper (1923). It will be seen that in the former species there is a coalescence along the middle line between the anterior (*am*) and posterior (*pm*) median dark areas.

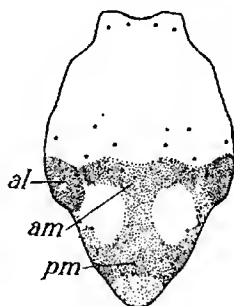


Fig. 2. Clypeus and vertex of 4th stage larva of *Anopheles culicifacies*, from Ceylon: *al*, *am*, anterior lateral and median dark areas; *pm*, posterior median dark area. (Drawn by O. Theodor.)

Edwards (1921) gives keys for identifying Palaearctic *Anopheles* larvae. He distinguishes that of *A. hyrcanus* by the presence of palmate hairs on "abdominal segments 1-7 (always?)", and *A. elutus* because it has them on 3-7; so far as Palestine is concerned the distinctions hold good, but palmate hairs are so often broken off that we find it easier to differentiate the two by the branched hair on the antenna. In *A. hyrcanus* it is about half as long as the antenna and has some ten branches; in *A. elutus* it is about a quarter of the length of the antenna and has about four branches.

Pupae of *Anopheles*.

The pupae of all our species except *A. multicolor*, *pharoensis* and *mauritanus* have been studied, by isolation of single larvae or pupae and determination of the adults which subsequently emerged, I have had at my disposal several examples of each

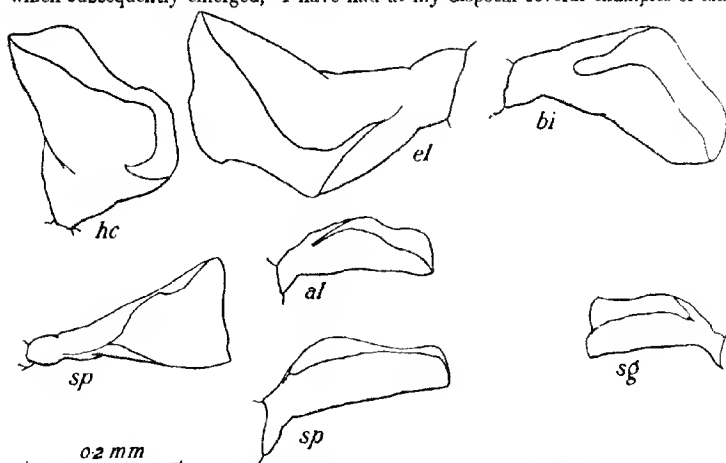


Fig. 3. Pupal trumpets of various species of *Anopheles*, uncompressed, drawn to same scale: *al*, *A. algeriensis*; *bi*, *A. bifurcatus*; *el*, *A. elutus*; *hc*, *A. hyrcanus*; *sg*, *A. sergenti*; *sp*, *A. superpictus*. (Drawn by O. Theodor.)

species. The separation of the pupae of the six species is by no means easy, but can, I believe, be performed by the use of the key which is given below. The species which present most difficulty are *A. sergenti* and *superpictus*, but I believe that the differences given in the key and shown in figures 3 and 4 are constant. It is unnecessary to describe the pupae, as such a description would merely enumerate the points shown in the figures. Many of the specific differences mentioned in the key, or shown in the figures, are probably of no phylogenetic importance; for instance, the pupae of *A. hyrcanus* and *elutus* appear to stand apart from the other species, including *A. bifurcatus*, which is believed to be a close ally of *A. elutus*. On the other hand, some of the characters may show true relationship. The two "*Myzomyia*," *A. superpictus* and *sergenti*, have very similar pupae, and the remarkable trumpet of *A. hyrcanus* resembles that of *A. mauritanus* as figured by Wesché (1910, Plate vi, fig. 20).

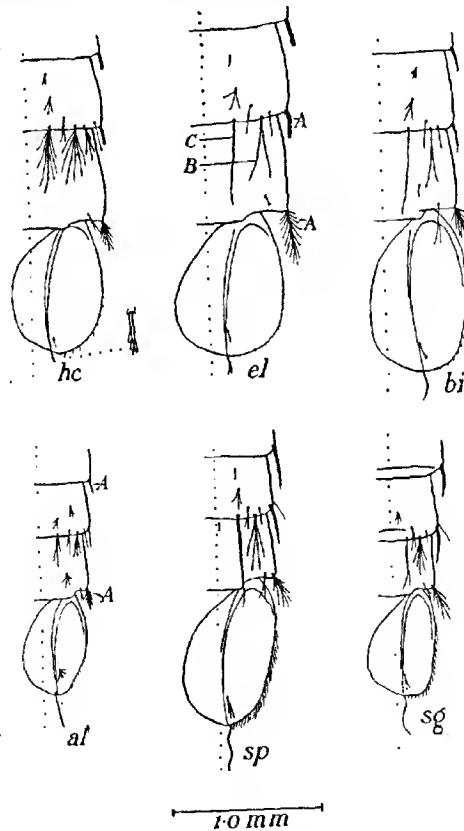


Fig. 4. Dorsum of 7th and 8th abdominal segments of *Anopheles*: hc, *A. hyrcanus*; el, *A. elutus*; bi, *A. bifurcatus*; al, *A. algeriensis*; sp, *A. superpictus*; sg, *A. sergenti*. (Drawn by O. Theodor.)

All the six species dealt with here, and one or two others of which figures are available, have a hair on the blade of the paddle, towards the posterior margin. This hair is

absent in all our Culicines,* and in all those Culicine pupae of which I can find figures in the Bulletin of Entomological Research. Its presence is probably characteristic of the Anopheline pupa.

I have only drawn abdominal segments 7 and 8, not that I regard the others as of no importance, but in order to simplify the illustrations and key. The shapes and proportions of the segments may be distinctive in the pupae themselves, but can hardly be so after the adult has emerged and the pupa skin been mounted.

The ratios of length to breadth (≈ 1) of paddles, and the ratio of length of meatus to total length of trumpet (Macfie and Ingram) are as follows:—

Species.	Paddles.		Trumpet.	
	Length. mm.	Ratio.	Length. mm.	Ratio.
<i>algeriensis</i>	0.7	1.25 : 1	0.38	0.35 : 1
<i>elutus</i>	1.0	1.35 : 1	0.48	0.27 : 1
<i>bifurcatus</i>	1.0	1.45 : 1	0.47	0.30 : 1
<i>hyrcanus</i>	0.8	1.20 : 1	0.42	0.50 : 1
<i>sergenti</i>	0.7	1.40 : 1	0.40	0.33 : 1
<i>superpictus</i>	0.9	1.45 : 1	0.45	0.20 : 1

I am a little sceptical as to the value of the trumpet index; figure 3 (*sp.*) shows two apparently undistorted trumpets of *A. superpictus*. In one the meatus appears much longer than it really is owing to apposition of the lips of part of the pinna.

Key to Anopheline Pupae.

1. Lateral seta (A) of segments 6 and 7 blunt; terminal spine of paddle branched 2
Seta A sharp; terminal spine simple 3
2. Trumpet short and wide (index 0.50 : 1); setae B and C of seventh abdominal segment with many branches *hyrcanus*
Trumpet of normal shape (index 0.27 : 1); setae B and C simple or with few branches *elutus*
3. Large pupa; length of paddle about 1.0 mm. *bifurcatus*
Smaller; paddles 0.9 mm. or less 4
4. Seta on blade of paddle with 5-6 branches.. .. . *algeriensis*
Seta with few branches, generally terminal.. .. . 5
5. Seta C of segment 7 reaching base of paddle; lateral margin of paddle rounded; length of paddle 0.9 mm. *superpictus*
Seta C of segment 7 not reaching base of paddle; lateral margin of paddle straight; length of paddle 0.7 mm. *sergenti*

10. The Malaria.

I have already discussed the malaria, when dealing with the *Anopheles* and their relation to man, and the problems of control; here I record some miscellaneous facts which have interested me, and which have not, I believe, been put on record.

* See Dr. Theodor's description of the pupae of 12 species, page 341.

Plasmodium malariae, the parasite of quartan malaria, is always rare in Palestine, and in 1922 was only found in just over 1 per cent. of the positive films examined. As the graph (fig. 1) shows, the quartan parasite is commonest in February, as it was also in the previous year, but it should be remembered that the figures for this parasite are very small. During Prof. Mühlens' investigation in Jerusalem, to which reference has already been made (p. 303), he found that 47.7 per cent. of the parasites were *P. falciparum*, 28.6 per cent. *P. vivax*, and as much as 20.1 per cent. *P. malariae*. I think I may say that all present-day workers in Palestine agree that a higher percentage than 1.2 per cent. is never seen. I understand from one of Prof. Mühlens' coadjutors that nearly all the examinations were made by the thick film method, which perhaps accounts for the discrepancy.

The graph in figure 1 is based on laboratory examinations for 1922, but there is no essential difference between the figures for 1920, 1921 or 1922. The benign tertian parasite (*P. vivax*) is commonest in August, the malignant (*P. falciparum*) in September, October and November.

I have already had occasion to refer to the nomadic habits of some of the settled population. Many of the hill-villagers own land in the Jordan Valley, and the men go down at certain seasons to cultivate it, and live while doing so in tents, reed-huts and caves. During the melon season watchmen live day and night in the fields, and there is a considerable movement from place to place of casual labourers who leave their villages to work at other peoples' harvests. Moreover, there exist many shrines to which pilgrimage is made at certain seasons. The grave of Moses (Nebi Musa) is, fortunately, situated in a salubrious spot and is visited about April. Elijah's Feast occurs in and round a cave on Mount Carmel; fortunately this place is also healthy, for the festivities fall in July and are attended by great numbers of Moslems, Christians, Jews and Druzes. Nebi Rubin, on the other hand, draws his Moslem visitors into a marshy spot and keeps them camped there for a full week in August; every year many of these pilgrims go home infected with malaria. The sum total of these wanderings, agricultural and religious, is considerable, and serves to confuse the worker in public health and to render it extremely difficult to decide on the amount of malaria that is caused by a particular spring or marsh.

The Bedouin, truly nomadic people, complicate the picture still further. In many parts of Palestine small tribes exist, the members of which are more pastoral than agricultural, or purely pastoral; each tribe has an area over which it wanders, and in some cases its limits are very much circumscribed, in others they are much wider. These people are somewhat suspicious of strangers, rather intractable, and intensely lethargic; it is therefore a matter of great difficulty to examine a dozen of their children in a morning, and accurate percentage statistics are quite unobtainable. They lead a very simple life, in a tent which is completely open on one side. There is no doubt however that some of the tribes are heavily infected and that they wander about spreading the infection. I first saw this at Hcsban, in Transjordan, where I was staying with Majid Pasha, of the Adwan tribe. His camp was pitched on a bleak dry limestone plateau, nearly 3,000 feet above sea-level and a couple of miles from the nearest water; in spite of this most of the children examined had huge indurated spleens. The explanation was that the tribal area of the Adwan includes a slice of dry hill country, their summer home, and a slice of well-watered Jordan plain to which they descend in winter and in which they acquire their malaria. The Beni Sagr, whose headquarters are near Beisan but who wander eastwards almost to Haifa, and southwards to the Wadi Fara (half way from Beisan to Jericho), are heavily infected. With Dr. Carley I examined 23 children in their camp near Beisan in June and found 11 enlarged spleens. The tribes in the dry and barren Negeb round Beersheba appear to be free from malaria. There exist perennial springs which breed mosquitos, for instance at Shellal, but the tribes do not generally camp close to these places.

III. OTHER ARTHROPODS OF MEDICAL AND VETERINARY INTEREST.

DIPTERA.

CULICIDAE.

Rather intermittent study of the Culicine mosquitos has been undertaken in conjunction with the more important work of breeding and collecting the Anophelines. In the second part of this paper (page 297) I have tabulated the association of different Anophelines with one another, and with certain Culicines. I shall not give similar tables for the Culicines, but shall mention their common associates as each species is discussed. When I have actual knowledge that a species bites man I have recorded the fact. Where the fact is not recorded one cannot presume that the species does not bite.

My assistant Mr. O. Theodor has described and figured a number of Culicine pupae in a paper which follows this.

Uranotaenia unguiculata, Edw.

Beisan : Shellal Dam ; Ain es Sultan, Jericho ; common from the end of August to the winter.

I have no records from spring, and my only one in summer is a single larva found at Ain es Sultan on 8th June ; I have made many other collections from that spot during spring and summer and never found this species. Larvae are generally found in large marsh areas, alone in cows' foot-prints, or associated with *C. perexiguus* or *C. tritaeniorhynchus*, and even *C. pipiens*. Goldberg's record from Jerusalem (Edwards 1921) is, I think, quite exceptional ; I know of no place near Jerusalem in which I should expect to find this species.

Theobaldia longiareolata, Macq.

Abundant in all parts of the country, and apparently at all times of the year.

The species is almost entirely urban, but I have found it breeding in Wadi Kabala with *Anopheles bifurcatus* and in a brackish runnel near the Ghoraniyeh bridge, R. Jordan, far from any human habitation. In May I passed rapidly through the country between Hebron and Massada, and was surprised to find larvae of this species and *Culex* sp. in many of the rain pools in the rocky beds of the torrents. Most of these pools are dry all the summer and scoured by spates in the winter, and it is difficult to see how the mosquitos can survive either season. In towns and villages one finds larvae of *T. longiareolata* in a great variety of places, for instance in cisterns, water-butts, small pits dug by builders for mixing cement, open cement tanks in gardens ; in all these situations the water is clean and clear. Equally often one finds larvae in thick muddy water, stirred up by rain, in ditches and caves, and the mud is so fine that it remains in suspension for long periods without incommoding the larvae. Larvae also occur in stinking discoloured water in which hides are soaked in tanneries, and foul-smelling waters from badly conducted laundries ; as it can live in such places as these it is curious that it appears not to breed in cesspits. The larvae of this species are commoner alone than with those of other species ; I have, however, found them with those of *C. pipiens* and *C. laticinctus* (commonly), and more rarely with *C. hortensis* and *S. fasciata*. I have never been bitten by this common domestic mosquito ; Storey has recorded that it bites man, rarely.

Theobaldia annulata, Schrank.

Afula, 3rd January (pupae) ; Caesarea, 25th February (male among vegetation) ; Caesarea, 22nd March and 14th April (larvae in an artificial pit in a marsh).

The species is, so far as we know, purely rural, in contrast to *T. longiareolata*. It is not common in Palestine and has been found only in the spring months ; search was made for it near Caesarea in May and June in the place in which it occurred in March and April, but it was not found.

Culicella morsitans, Theo.

Caesarea, 22nd March (larvae with those of *T. annulata*, in a small pit in a marsh). Barraud's (1921) record was for April at Haifa, so presumably the species is only to be found in spring. Edwards (1921) has overlooked this record, and states that the species has not been recorded from Asia.

Taeniorhynchus buxtoni, Edw.

South shore of Lake Huleh, 3rd September; Nahr ez Zerqa, 31st May, 24th June.

This species is common in large marshes, and bites viciously after sun-down; the bite, to me at any rate, is unusually painful. The male and the larvae are at present unknown.

Taeniorhynchus richiardi, Fic.

Cropper's specimens from Lake Huleh are still in the British Museum, and Edwards tells me that they undoubtedly belong to this species and not to the preceding one. No subsequent collector has obtained it.

Ochlerotatus caspius, Pallas.

Apparently common throughout the coastal zone wherever there are marshes, and also throughout the Jordan depression, all through the summer.

Females often bite in broad daylight, even if one is standing in the sun, and at Beisan we noticed that on windy evenings, when no *Anopheles* were biting, this species was still active. In the marsh of the Namein River at Akka at dusk I was myself bitten exclusively by *Anopheles algeriensis* and *hyrcanus*, and my horse was bitten almost entirely by *O. caspius*. Larvae occur equally in brackish and fresh water. They seem to prefer a rather large expanse of shallow water and one does not find them frequently in hoof-marks. The flood pools by the side of the River Jordan in spring time breed this species in immense numbers, and make life near the river very unpleasant. The larva is generally found alone, occasionally with larvae of *Culex tritaeniorhynchus* and *C. perexiguus*.

Ochlerotatus mariae, Serg.

The only locality which I know in Palestine is the one discovered by Barraud at Athlit. Here *O. mariae* breeds in holes in the rocks just above tide level; the holes are filled by the spray and must at times be saltier than the sea owing to evaporation. At the time of my visit (10th November) larvae and pupae were abundant in water which could not be distinguished by taste from pure sea-water; the pH of this water was more alkaline than 8.2 (no correction for "salt error" has been made), but we had no indicator with us which would read beyond this point. In this place the larva of *O. mariae* has no associate.

Ochlerotatus detritus, Hal.

Beisan, 3rd January (adults); Caesarea, 27th February (biting at dusk and sitting in vegetation by day—Theodor); Nahr ez Zerqa and Caesarea, 14th April (adults).

Quite a common species in spring.

Stegomyia argentea, Poiret (*S. fasciata*, F.).

Common in towns along the coast and in the Jordan depression (Tiberias, Jericho), probably at all times; occurs in Jerusalem, in summer only, so far as I know. I think it probable that the winter exterminates this species in Jerusalem, and that it re-colonises the city every year, possibly coming up from the coast in railway trains. Larvae may be found alone or in company with those of *Culex pipiens* and other domestic species.

Culex modestus, Fic.

Beisan, 15th June (both sexes bred). This confirms Austen's (1921) record which was based on female specimens only.

Culex hortensis, Fic.

Widely distributed, in spring. I have records of larvae from every month from January to April, one only in May (Wadi Kabala, 2,000 ft.), and Barraud's for July (Damascus, also at a considerable altitude). I know of no records at all for other months. The larvae are generally found in masses of green algae, and for that reason sometimes occur with *C. perexiguus*; this however is unusual. Other occasional associates are *C. tipuliformis*, and *C. mimeticus*. I have twice found the larvae in brackish water, in a watering hole near the Kishon, associated with *C. pipiens*, and in a trickle of water near the Ghoraniyeh Bridge, R. Jordan, with larvae of *Theobaldia longiareolata*.

Culex apicalis, Adams.

Wadi Kabala, 10 miles W. of Jerusalem, 15th May (both sexes bred, determined by Edwards).

The larvae were found associated with those of *A. bifurcatus*, *C. hortensis*, *mimeticus* and *pipiens*, in a heavily shaded pool. This species is new to Palestine.

Culex mimeticus, Noé.

Seil Amman, Transjordan, 20th-30th August; Ain es Sultan, Jericho, 18th April; Wadi Kabala, 15th May.

The Amman locality has already been described (page 295). At Ain es Sultan the species has been found once only in many collections made; probably therefore it has a small and definite number of broods in the year, in contrast with *A. superpictus*, which occurs there continuously through the summer months. Its associates in Wadi Kabala have been listed under *C. apicalis*.

Culex tritaeniorhynchus, Giles.

Mejdel, Sea of Galilee; Beisan; Shellal Dam.

Adults bite man. Larvae are common in larger marshes, for instance that at Beisan, but they do not generally associate with other species. They prefer clear water (e.g. in foot-prints) to water containing algae, and are often found in newly made floods, where uncontrolled irrigation has been allowed. They therefore differ in their habits from those of the very similar *C. perexiguus*, which prefers masses of filamentous algae. They are very often found alone, in their particular little pool or hoof-mark, or associated with *Uranotaenia unguiculata*.

Culex perexiguus, Theo. (*C. univittatus*, Theo., Barraud, 1920).

Beisan; Akka; Amman, Transjordan; Wadi Latron; Shellal; Afule; Ain es Sultan, Jericho.

Common, in nearly every month of the year. Adults bite man and enter houses and mosquito-nets for that purpose; they also bite dogs. Larvae occur in a variety of places, great marshes and small overgrown streams, and show a preference for masses of filamentous algae. In such places the larva is associated with those of *C. pipiens*, *tipuliformis* and *hortensis*. I have never found it alone.

Culex tipuliformis, Theo.

Akka, 8th June (larvae in water which had leaked from an aqueduct and was full of slimy filamentous algae); Qantara, Suez Canal, 20th June (larvae in an open drain); Afule, 3rd January; Qazaza, near Khedeira, 31st May.

Not in my experience a common species. Adults emerge from the pupa at almost any hour of the day or night.

Culex laurenti, Newst.

West shore of Lake Huleh, 30th August (larvae in water 12 inches deep, among grass and sedge).

From these larvae males were bred, and examined by Edwards. This confirms Austen's (1921) two records, based on females only. Palestine is the only country, outside Africa, from which this species has been recorded.

Culex laticinctus, Edw.

Known from Tiberias (type locality); Jericho; Jerusalem; Haifa; Nablus; Artuf.

Larvae are quite common, apparently at all times of the year; they occur in cisterns, water-butts, and open concrete tanks. So far as I know this species is entirely urban, more exclusively so than *C. pipiens*. Its associates are that species and *Theobaldia longiareolata*, and its larvae are not often found alone.

Culex pipiens, L.

Found, I suppose, in every village and town in Palestine, at all times of the year. It breeds in water-butts, open tanks, cisterns and rock tombs; it is, I believe, the only species which breeds in cesspits. The extremely dry spring and summer of 1923 have tended rather to increase than diminish this species in the better parts of Jerusalem, because people have saved their bath-water and bedroom slops for their gardens. In urban areas it is associated with *C. laticinctus* and *T. longiareolata*, but its larvae often occur alone.

I have been very much interested to discover that *C. pipiens* is by no means strictly confined to towns and villages. It has been found breeding in the Shellal Dam, perhaps fifteen miles from any house, except a "house of hair," as the Bedouin call their black tents; also in a temporary winter pond at Afule, and in the running Wadis Latron and Kabala. In such places *C. pipiens* is associated with such rural insects as *Uranotaenia unguiculata*, *C. hortensis* and *mimeticus*, and others, and with rural Anophelines.

A careful scrutiny of many Palestine specimens has been made by Edwards without revealing the presence of *C. fatigans*; this confirms Barraud's conclusions and agrees with the absence of *C. fatigans* from Egypt (Storey). One would be disposed to say that it also explains the absence of *Filaria bancrofti* from Palestine, were it not that both *C. pipiens* and *C. fatigans* are listed as hosts of the microfilaria by Manson-Bahr.

PSYCHODIDAE.

The records given below are all based on the examination of the genitalia of male specimens.

Phlebotomus papatasi, Scop.

Tiberias, 13th May; Jerusalem, June, July (abundant); Jaffa, July.

Phlebotomus minutus, Rond.

Haifa, June, July (in great numbers); Jerusalem, 31st May (scarce).

Ansten (1921) records *P. minutus* var. *africanus*, Newst., from various localities in the Jaffa area. I have gone into the question in detail with the aid of Newstead's original description and find that none of my specimens are var. *africanus*; on palpal characters they are clearly of the typical race; the wing characters are less definite and not measureable.

Phlebotomus perniciosus, Newst.

Jerusalem, 28th May (one male only).

New to Palestine, but has been recorded from Syria, according to Larrousse.

CHIRONOMIDAE.

Leptoconops bezzii, Noé, var.

Khdeira, 31st May; Jericho, 31st March.

A very irritating insect, which occurred in great numbers on both occasions. To me, at any rate, the irritation was caused not by the bites, but by the presence of the insects on my face and in my eyes and ears. *L. bezzii* is new to Palestine, and I believe to Asia. "In the Palestinian specimens of this species the antennae, especially the last segment, are rather longer than is indicated in Carter's descriptions; the tooth on the claw is small and sometimes difficult to detect." (F. W. Edwards, in litt.)

SIMULIIDAE.

Simulium aureum, Fries (*bracteaum*, Coq.).

"Very common on Carmel, and also observed at Rameh, near Safed, and at Akka. Its bite is most irritating, and it seems to prefer to obtain blood from a number of punctures, as it seldom settles down to feed in the same way as a mosquito does" (G. E. Bodkin).

Our knowledge of this genus in Palestine is almost confined to what Austen has written (1921, and 1923, p. 276, footnote).

TABANIDAE.

Information relating to the Tabanid flies of Palestine is at present almost confined to two papers by Austen (1920, 1922). Perusal of them gives the impression that the number of species is great, but that few of them are at all common, and this was till recently my own opinion; I now find that several species are common and widely distributed, but that their season of flight is very short. These are presumably of economic importance, and I shall confine my remarks to them and omit the rarer species. Mr. Theodor and myself have had the good fortune to add to the fauna of Palestine two species of *Chrysops* (*C. buxtoni*, Austen, and *C. compacta*, Austen) and five of *Tabanus*, (*T. agnitionalis*, Austen, *T. kerteszi*, Szil., *T. sufis*, Jaenn., *T. bromius*, L., and *T. cuspidatus*, Austen). On the other hand we have failed to find two species of *Haematopota* and four species of *Tabanus* obtained by Austen, and the possibility of further novelties is by no means exhausted. None of the early stages of any of our species has yet been found, or even looked for.

Chrysops punctifera, Lw.

This species is confined to the coastal region (Akka to Wadi Ghuzze, south of Gaza) and the Jordan depression (Huleh to Jericho), and has never been taken in the hills, with the exception of the specimen recorded by Austen (1922) from Zahle at a considerable altitude in the Lebanon.

There are many records in every month from April to August, three for September (Austen, 1920) and one for October (Wadi Latron, 3rd Oct., female crawling on leaves over water, probably about to oviposit). It is impossible from a consideration of the records to say how many broods there are. The species sucks the blood of horses and cattle; males were observed sitting on grass in the mouth of a wide agricultural well at Haifa, 28th May, and Mr. Theodor watched one feeding from a cow's faeces with *Sarcophaga*, etc. (14th April, Benjamina.) The species is often common, and on the whole I do not know whether it or *H. sewelli* is the commonest Tabanid in Palestine.

Chrysops buxtoni, Austen.

Nahr ez Zerqa, 31st May (common) and 24th June (rare) (Theodor).

So far as is known this species is confined to the great marshes between Khedeira on the south and Zichron Yacob on the north, a distance of about 8 miles; it has only been found in May and June, but is not at all rare. Females bite cattle and horses; males may be caught on the flowers of Umbelliferae.

Haematopota sewelli, Austen.

This species is common throughout the coastal zone from Wadi Rubin and Rehoboth in the south to Akka in the north, and throughout the Jordan Valley; I have no records from the hill country.

The species is found in a variety of places, round the great swamps of the Namein and Zerqa rivers, and also in such places as Wadi Hamam, near Tiberias, and Jericho, where it presumably breeds in the beds of small rapid streams.

I have records for April, May, June and September, October, November; the majority of records are for May and October, and the species is clearly double-brooded. *H. sewelli* bites horses commonly and males poise themselves in the air round the horse's head while the females are sucking. The males have also a habit of flying round man, possibly in search of females, and at these times may be easily caught if one can only see them. I have never noticed males of *Chrysops* or *Tabanus* flying round horses or men in a similar way.

Haematopota innominata, Austen.

Wadi Maleh, Jordan Valley, 4th May; Nahr ez Zerqa, 31st May; near Artuf, Wadi Surar, 22nd May.

This species is common in its short season; all the known specimens have been taken between 4th May and 24th June, either in the coastal zone between Akka and Jerisheh, near Jaffa, or in the Jordan Valley (Wadi Maleh). The species bites horses, cattle and donkeys, and Mr. Theodor took males sitting on stones in Wadi Surar, near Artuf.

Tabanus gigas, Herbst.

Nahr ez Zerqa, 14th April (one female, feeding on a cow).

Tabanus lunatus, F.

Jerusalem, 15th April; Tayibe, N.E. of Ramalla, 28th April; near Fukoa, E. of Jenin, 2nd May; Samria and Wadi Maleh, Jordan Valley, 4th May; Kafrouieh, near Artuf, 22nd May.

This species is remarkable because its range includes the coastal zone, Jordan depression and hill country. During April and May it is sometimes extremely common; near Fukoa and Wadi Maleh I took as many as eight in my net at one time, by scraping the belly of my horse, and I noticed that the flies sat for preference on

the edge of the girth, and not on the horse's skin itself, while they were sucking blood. Females suck also the blood of donkeys and cattle, and males sit on the blossoms of yellow Umbelliferae (*Foeniculum*, *Colladonia crenata* and others); I have not seen them on any white Umbelliferae. The species was observed in greatest number wherever my route crossed the beds of streams which are dry for the whole summer; this was particularly noticeable near Fukoa, where the wadi bed was an expanse of cracked clay. On the other hand, the water in Wadi Melah and in the little runnel at Samria is perennial, and the species was abundant in both these places.

Tabanus nemoralis, Mg.

Wadi Najmeh, Jordan Valley, 28th April, biting horses.

This species attacked our horses during a ride from Tayibe to Jericho and was locally common at about sea-level in the upper part of the Wadi Najmeh, above its precipitous descent to the Jordan depression. *T. nemoralis* is apparently a hill species, emerging in April and May.

Tabanus autumnalis, L.

Quite a number of records are available. The species is widely distributed in the coastal zone, the Valley of Jezreel and the Jordan Valley, but has only been seen commonly on one occasion (Nahr ez Zerqa, 31st May—Theodor).

Most of the records are for April and May; I have none for June and two for July; possibly therefore the species is double-brooded. *T. autumnalis* bites mules, donkeys, and cattle; males may be taken in the middle of the day resting on the shady side of tree-trunks, telegraph posts, etc. In the male the lower crescentic area of the eye is of the same colour as the dorsum of the thorax; the rest of the eye is pale grey-brown, there being no metallic reflections.

Tabanus rupinae, Austen.

Jericho, 5th July; Wadi Kelt, 16th, 23rd May.

Confined, so far as is known, to the lower end of the Jordan Valley and its tributaries; adults found in May, June, July.

Tabanus arenivagus, Austen.

Rehoboth, 18th October; Jaffa, 17th October; Rafa, 20th October; Ness Ziona, 16th October (Bodenheimer).

This interesting species is confined to the dune area from Jaffa in the north to Rafa in the south, and is found only from September to November, in which respect it is unique among our species. It is quite common at the right time and place. One must suppose that it breeds in the shallow wells which are sunk in depressions in the sand dunes.

Tabanus leleani, Austen.

A number of records are available, to supplement Austen's. The species is widely distributed in the coastal zone from Wadi Ghuzze in the south at any rate to Nahr ez Zerqa; in the Jordan depression from Jericho to the Valley of Jezreel. It has been taken in every month from April to August and is often quite common.

Tabanus pallidipes, Austen.

Beisan, 24th–30th July, early August; males entering houses during the heat of the day.

DOLICHOPODIDAE.

Medeterus sp.

Every year small flies of this species appear on the windows of Government House, Jerusalem, in May, in very great numbers. They always cause consternation, and will probably prove as much trouble to succeeding entomologists as they have to me. My specimens were stated by the Imperial Bureau of Entomology to represent an undescribed species.

MUSCIDAE.

Musca domestica, L.

Jerusalem.

Musca vicina, Macq.

Amman, Transjordan, September; Jerusalem, June.

Immense numbers of larvae were found in the fur of a sick rabbit in the laboratory at Jerusalem. The fur had become soiled with faeces. From these larvae I have bred specimens which Patton has identified as *M. vicina*.

Musca nebulosa, F.

Jerusalem.

Musca sorbens, Wied. (*humilis*, Wied.).

Amman, September.

Musca autumnalis, De Geer.

On horses, near Beisan, May.

The species of the genus *Musca* which occur in Palestine have hardly been studied at all, and nothing is known of their relative importance as carriers of disease. The identifications given above are Patton's.

Cyrtoneura (Muscina) stabulans, Flin.

Jerusalem, end of May.

Large numbers of both sexes emerged from a cage which contained larvae and pupae of the Arctiid moth *Ocnogyna locwi*; presumably the Muscid had bred in the food supplied for the moth larvae.

Muscina pabulorum, Flin.

Haifa, 1921.

Phormia azurea, Flin.

Haifa, 25th May.

Limnophora variegata, Stein.

Jericho, 24th March; Lydda, 1st December.

A common species in many parts of Palestine. It feeds greedily at fresh human faeces, but does not often enter houses, so its importance is probably slight.

Calliphora erythrocephala, Mg.

Common everywhere, in and out of houses. I have bred *Nasonia (Mormoniella) brevicornis*, Ashm., from pupae of this species. The method of rearing isolated larvae on peptone-agar "slopes" gives excellent results with this species, and with *Lucilia*, *Sarcophaga* and *Musca*.

Chrysomya albiceps, Wied.

I have specimens from Jerusalem and Haifa, and probably the species is widely distributed. I have never captured or bred this insect, except in April and May, or in September and October, and I believe that it is strictly double-brooded. Patton (May 1922) describes the differences between Palestinian and Indian specimens, but refers them all to *C. albiceps*, Wied. In another paper (Jan. 1922) in discussing this species in India he says that "the second, but more particularly the third stage larva of *albiceps* is entirely predacious, feeding on the larvae of other CALLIPHORINAE," and goes on to describe the habits of the female, who lays her eggs among those of other species of *Chrysomya*, etc.; he states also that the mouth-parts of the larva are modified to suck juices of other larvae. In Palestine, larvae are not to be found in fresh carcasses, but after the meat has become semi-fluid and extremely offensive immense numbers of the larvae of *C. albiceps* may be found in it; at this stage most of the *Lucilia* and *Calliphora* larvae have pupated. I have never seen *C. albiceps* larvae attack one another or those of other species in nature, and they lie close together in heaving masses in exactly the same way as the larvae of other flesh-flies do, feeding as I suppose on the juices of the meat. Moreover, if one places single second-stage larvae in test-tubes on slopes of peptone-agar, one obtains full-sized adult flies, which emerge on the same day as the controls which are allowed to remain in the carcass. On the other hand, if these second-stage larvae are put on agar slopes with a few larvae of *Lucilia* or *Calliphora*, they invariably eat the latter. The conclusion is that in Palestine this species is not so exclusively predacious as in India.

Chrysomya marginalis, Wied.

In 1922 I caught adults and also bred them from larvae in carcasses in May and in October, in Jerusalem. In the spring of 1923 I failed to obtain the species, though I exposed a series of dogs' and guinea-pigs' bodies; this was disappointing, as the larva is very imperfectly known. The species has, I believe, not been recorded from any part of Asia except Quetta, Baluchistan. It is commonly parasitized by *Nasonia* (*M.*) *brevicornis*, Ashm.

Lucilia sericata, Mg.

Common in Jerusalem and doubtless in other parts of the country. I have larvae from three cases of myiasis due to this species. From the first case, a shell wound in a child near Nablus, 1st and 2nd stage larvae (determined by Patton) were sent me by Dr. Jemil Tucktuck. From the second I received mature larvae; the subject was a boy who fell and fractured his forearm, tearing the veins and arteries, so that gangrene followed; this occurred at Kerak ("Kir of Moab"), S.E. of the Dead Sea; fourteen days later the boy came to Beersheba Hospital, and Dr. Abu Ghazaleh amputated the arm and sent me the larvae. The third case was a severe burn which was allowed to become septic and full of maggots of this species before the patient was brought to hospital.

Lucilia nobilis, Mg.

Haifa, 1st May; Jerusalem, 23rd April.

Philaematomya crassirostris, Stein (*insignis*, Austen).

Jerusalem, 14th August, on donkey; Beisan, 24th July, on cow.

Austen (1921) particularly notes that he did not find this species in the earlier months of the year, not in fact until September; his suggestion that "had cattle been examined, the fly would very possibly have been encountered earlier" is probably correct.

Philaematomyia lineata, Brunetti.

Wadi Maleh, Jordan Valley, 4th May. Abundant on horses.

Stomoxys calcitrans, L.

Jerusalem, May; Wadi Maleh, Jordan Valley, 4th May.

The flies of this genus are abundant and troublesome. Most of my specimens are in England, awaiting accurate determination.

Lyperosia irritans, L.

Bir Salem, Ramleh, 2nd November; Khedeira, 31st May (on horses' withers).

Sarcophaga hirtipes, Wied.

Khedeira, 31st May.

Sarcophaga striata, Schin.

Haifa, 28th May.

Members of the genus are common, but nearly all my material awaits determination at the British Museum.

Wohlfahrtia magnifica, Schin.

Near Tiberias, June (ethmoid cells of woman, *Dr. Herbert W. Torrance*); Nablus, June (otitis in child, *Dr. W. K. Bigger*).

Dr. Torrance's case, of which he gave me a very full report, was a middle-aged woman from a village near Tiberias. She had suffered four days from severe epistaxis, and was feeling very weak, fevered and ill; she could hardly stand and had a foetid discharge from the nose, and slight fever. The root of the nose and the region of the frontal sinuses were tender on palpation. The nose was douched frequently, and two large larvae washed out through the posterior nares. The patient was stupid, but by dint of putting leading questions Dr. Torrance obtained a statement that five days before admission she had been gleaning in the fields; she thought she felt a fly in her nose, and she sneezed a good deal. Next evening she had a very severe left-sided frontal headache, and she extracted two "leeches" from her nose; when she was shown the larvae extracted in hospital she called them "leeches." In this case therefore only four larvae were accounted for. In the case of the child with an aural infection, from Nablus, more than a dozen larvae were sent me.

The identification is Major Patton's and is based on the larval structures; so far as I know the fly itself has not been bred or caught in Palestine.

OESTRIDAE.

Rhinoestrus purpureus, Brauer.

Near Samaria, 2nd June.

Hypoderma silenus, Brauer.

Dog River, Beirut, Syria, 28th March; I believe that the species is not known except from Egypt, and that it is a parasite of the donkey.

Gastrophilus haemorrhoidalis, L.

Samria, 8 miles S. of Beisan, 4th May.

Three of these flies, buzzing round my horse's fetlocks.

Gastrophilus bengalensis, Macq.

5 miles E. of Jenin, 2nd May (on horse).

Larvae of a species of *Gastrophilus* are very common in horses' and donkeys' stomachs.

Oestrus ovis, L.

Ticho (1917, 1923) has described a number of Palestinian cases of infection of the conjunctival sac by this insect.

HIPPOBOSCIDAE.

Hippobosca equina, L.

H. capensis, v. Olf.

These two flies are extremely common on horses and dogs, respectively, in every part of the country in spring and summer. One frequently sees thirty *H. equina* clustered under a horse's tail, and causing apparently no inconvenience.

Lynchia maura, Big.

Artuf, 12th April (on pigeon).

Lipoptena caprina, Austen.

Abu Ghosh, W. of Jerusalem, 16th May; Jerusalem, 5th July; Nablus, 26th April; Nahr ez Zerqa, 14th April (adults and larvae). Probably common everywhere on goats.

Austen's description (1921) of the adult was made from dried material; since it was published, Ferris and Cole have published a series of figures and descriptions of species of *Lipoptena* and other genera, made from spirit material which had been treated with potash and mounted in balsam, uncompressed. For the sake of comparison I now supply figures (fig. 5) and a short descriptive note, made from similar preparations; the description is not intended to be complete, but rather to supplement Austen's, by drawing attention to points which are best seen in cleared material.

Head: the largest and most posterior of the cephalic setae is doubled on the left side in one male examined. *Thorax*: the prothoracic spiracle nearly circular in outline. Prealar setae in two rows, those in the first short and blunt, those in the second 4-5 in number and long. The scutellar pit described by Austen is, as he

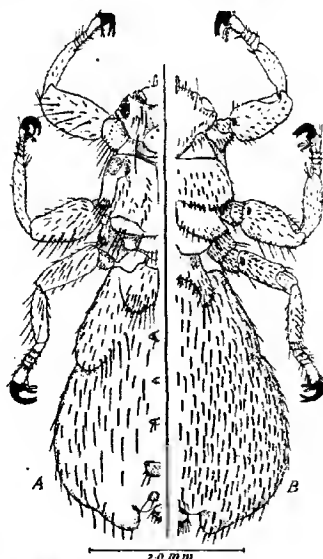


Fig. 5. *Lipoptena caprina*, Austen: A, dorsum; B, venter.

suggests, a phenomenon due to desiccation; I can see no sign of it in my preparations. In the female the bristles on the posterior outer margin of the mesosternum, overhanging the base of the leg, are stout and peg-like; in the male they are similar, except one which is long and fine and reaches the coxa of the third leg. The corresponding bristles on the metasternum are weaker and show no difference between the sexes. *Legs*: a conspicuous row of 5-6 bristles on dorsal surface of posterior margin of first coxa, and a less developed row on ventral surface. Group of three small sensory pits (?) on ventral surface of base of each femur. Single spine at inner angle of apex of first tibia, and double spine in same place on second tibia; no corresponding spine on third tibia but a series of four stout bristles. Claws of each leg equal. *Abdomen* of female: dorsal mediobasal area heavily chitinized, with convex posterior margin beset with long fine setae; lateral and posterior to it an area less chitinized, the posterior margin of which is indefinite, but marked by a curved row of still longer setae; rest of dorsum very weakly chitinized, finely and evenly hairy; dorsal plates as described by Austen, but behind his fourth ("terminal") plate is a pair of plates which are probably invaginated in dried material and therefore not visible. Ventral surface with mediobasal area heavily chitinized, its posterior margin concave and beset with short peg-like setae; remainder of venter weakly chitinized, more hirsute than dorsum. Abdomen of male as described by Austen. *Male genitalia* (fig. 6). These organs consist of a heavily chitinized median rod, presumably the aedoeagus (oe), which articulates basally on a bow-shaped apodeme

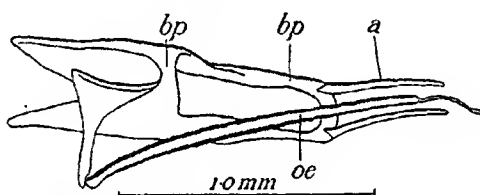


Fig. 6. *Lipoptena caprina*, male genitalia as seen from below: a, pieces flanking aedoeagus; bp, basal plate; oe, aedoeagus.

and terminates distally in an extremely fine membranous tube. The distal part of the aedoeagus is flanked by two pieces (a) which have been forced apart for the sake of greater clearness in my figure; these pieces are articulated on a complex basal plate (bp) bearing near its base the bow-shaped prolongation to which the aedoeagus articulates. I am unable to homologize these structures with those of *L. mazamae*, *depressa* and *traguli*, as figured by Ferris & Cole, but I agree with those authors that the whole question cannot be dealt with until a number of specimens of several species are available.

Note. Among the species figured by Ferris & Cole, *L. caprina* is nearest to *L. cervi*, L., which it resembles in the nearly circular spiracle, the two rows of prealar setae, the tibial spines, equal claws (in which it shows also a resemblance to *L. traguli*, Ferris & Cole) and the possession of four dorsal abdominal plates. It is, however, distinct from *L. cervi* in innumerable characters, as can be seen from a comparison of the figures.

Mature larva (fig. 7) as deposited by female in captivity (4 specimens). Length, 2.8-2.9 mm.; dorsoventral depth, 1.8 mm.; width, 2.0-2.2 mm. Colour pale yellowish brown, dorsum and venter darker; at the posterior end a heavily chitinized spiracular plate, which is black and projects slightly. This area is crossed by a horizontal indentation. That surface which I presume is the ventral is slightly flatter than the dorsal, and bears a minute chitinous ring (an, fig. 7) immediately anterior to the heavily chitinized area. I presume that this is the anus; in the figure published by

Ferris of the larva of *Nycteribia pedicularia*, Latr., a small rounded mark ventral to the spiracles is shown, and I suggest that this is probably also the anus; in Ferris' description no mention of it is made. On the other hand, in discussing the larva of *Ornithomyia strigilecula*, which he figures, he refers to a "large circular opening" (in the middle of the spiracular plate) "which is possibly the anus, and appears to be closed by internal operculum." I find it very difficult to believe that the anus occurs

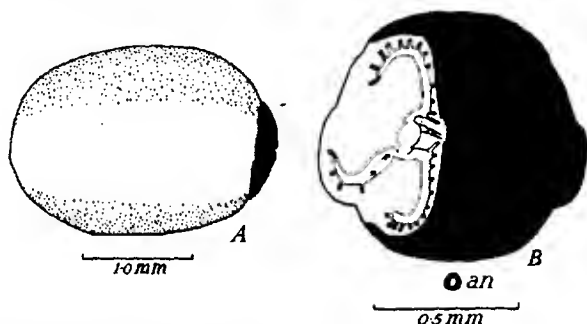


Fig. 7. *Lipoptena caprina*: A, larva, seen from the side; B, stigmatic plate of larva, the right side showing its normal appearance, the left the underlying tracheae, seen by transparency; an, anus.

in such a place as this,* and Dr. Keilin, of the Molteno Institute, Cambridge, to whom I referred the matter, suggest that "in Ferris' fig. 4 of *Ornithomyia*, the central dark spot must be the place of insertion of a strong muscle which moves the spiracular plate." It would not be easy in a heavily chitinated plate to distinguish between a circular depression and a hole closed by a plug. The structural details of the heavily chitinated spiracular plate of *L. caprina* can only be made out with difficulty, because of its blackness; I have found it impossible to decolorize it either with sulphur dioxide solution, or with bleaching powder, or with hydrogen peroxide.

Figure 7, B, is drawn from a specimen which was treated with potassium hydroxide (10 per cent.) for several days. The right side of the figure shows the only surface features, a number of pin-points of light on a black background. The left side shows the three tracheal trunks which open at these "pin-points," the spiracular pores; the tracheal trunks unite in a spherical chamber, from which a rather thick-walled trachea passes away deeply towards the middle-line. It is tempting to derive the three groups of spiracular pores from the three slits which occur in the posterior spiracles of so many brachycerous larvae. The larva of *Ornithomyia* shows a similar arrangement of three groups of spiracular pores, each connected with a tracheal trunk; the larvae of *Nycteribia* and *Aspidoptera* do not show this arrangement (Ferris).

SIPHONAPTERA.

The practical importance of fleas is that bubonic plague is endemic in the ports of the Egyptian delta, with which the coastal towns and villages of Palestine are closely connected by trade. Presumably as a result of this, sporadic cases and small outbreaks occur in Haifa, Jaffa and other places nearly every summer. The principal rat flea of the coast is *Xenopsylla cheopis*, and I have endeavoured to show (Buxton, 1923) that the epidemiology of plague in Palestine and elsewhere may be partly explained by

* I have a letter from Prof. Ferris, in which he states that he has re-examined his larva of *L. masamas* and found the ring, and that he agrees that it is no doubt the anus, and that his interpretation of the larva of *O. strigilecula* requires modification.

supposing that temperature and humidity taken together form a complex factor which determines the seasonal prevalence of *X. cheopis*, and indirectly of the plague itself. The breeding experiments on which the hypothesis is founded are Bacot's, and are not quite sufficient to enable one accurately to delimit the conditions favourable and unfavourable to the *Xenopsylla* larva; moreover, the statistics for temperature and humidity of Jaffa and other places were ordinary meteorological means, taken in a white screen, and they require to be corrected to suit the conditions prevailing under floors and in other breeding places of rats and fleas. In spite of these limitations, the line of investigation which I described is valuable even in its crude form, as is shown by the fact, both in theory and practice, that plague is rare or absent in Jaffa in mid-winter, while it is absent from Suez in midsummer; in the Mediterranean ports of Egypt it should be, and is, endemic, but commonest in summer.

The epidemiology of plague in Palestine might easily become complicated, because several wild mammals which are susceptible are common, and because several of them are close associates of man. *Acomys dimidiatus*, a spiny mouse, belongs to the "desert" element of the fauna, and is distributed from Sinai and the Negeb northwards to Jerusalem, where I trapped a series in my garden and house. I found no fleas on them, but the common flea of *A. cahirinus* in Egypt is *X. cheopis* (Bacot, Petrie & Todd). Many genera and species of Gerbilles (*Meriones*, *Gerbillus*, etc.) inhabit the coastal plain and the south of Palestine. One at any rate, *Gerbillus allenbyi*, Thos., is common enough in the orange gardens and sand dunes on the edge of the town of Jaffa; we know nothing of the susceptibility of this particular gerbille to plague, but several of its congeners in other countries are liable to epizootics, and one fears that plague in the rats in Jaffa might spread to the gerbilles and so gain access to villages and become a widespread epidemic. Fleas are not common on *G. allenbyi* at Jaffa, but I have taken one or two females of *Xenopsylla* sp. incog. from it. From a dozen live *Meriones sacramenti*, Thos., from Beersheba, I obtained a very few *X. ramesis*.

Another mammal which is possibly dangerous is a ground squirrel (*Citellus*) which is known from the hill country of Transjordan; it is quite possible that it occurs in Palestine without our knowing it. Of truly domestic rodents we have *Mus rattus*, known to be common in Haifa, Jaffa and Jerusalem; *Mus norvegicus* (*decumanus*), at present only known from the ports, where it appears to outnumber *M. rattus*; *Mus musculus* and *Mus gentilis*. Of these last two closely related species, *M. gentilis* occurs in many of the towns, and was common in my house at Jerusalem; *M. musculus* has been trapped at Jericho, so one may suppose it is widely distributed.

The following records show the species of fleas which I have collected up to the present.

Ctenocephalus felis, Bouché.

Jaffa, July and August, on domestic rabbit (in great numbers), man and dog; Jerusalem, September, on man; Carmel, on dog; Hebron, on fox.

Ctenocephalus canis, Curtis.

Jaffa, August, on dog and man; Jerusalem, August, on man; Carmel, on dog; Hebron, on fox.

Pulex irritans, L.

Jaffa, July, on man (commonly) and *Mus norvegicus* (rarely); Jerusalem, many months, on man; Carmel, Haifa, on porcupine (*Hystrix hirsutirostris*), September, (Bodkin); Hebron, on fox.

Leptopsylla musculi, Dugés.

Jerusalem, October on *Mus rattus* (only on one individual out of 27 examined, but this individual had thirteen fleas); Jaffa, on *Mus rattus* (rare).

Xenopsylla cheopis, Roths.

Jaffa, July, September, on *Mus rattus*, *M. norvegicus*, and man; Jerusalem, September, October, on *M. rattus* (9 rats out of 27 harboured this flea).

This is clearly the common rat flea of the country, and the principal vector of *Bacillus pestis*.

Xenopsylla ramesis, Roths.

Beersheba, November, half-a-dozen fleas on a dozen *Meriones sacramenti*, Thos.

Xenopsylla sp. inc.

Jaffa, December, a few females on *Gerbillus allenbyi*, Thos. Rothschild regarded them as probably new, but the material was insufficient for description.

Ceratophyllus londiniensis, Roths.

Jerusalem, September, on *Mus rattus*.

Ceratophyllus fasciatus, Bosc.

Jerusalem, October, on *Mus rattus*. Though we have found only one of these fleas on a single black rat out of 27 examined, its presence in Jerusalem might seriously complicate matters if plague broke out. If the climate of Jerusalem is studied by the method I have indicated (1923), it will be found to be favourable to *X. cheopis* in summer and *C. fasciatus* in winter; presumably therefore plague might become endemic.

Archaeopsylla erinacei, Bouché.

Jerusalem, various dates, on *Erinaceus roumanicus sacer*. This flea is as abundant on the hedgehog of Palestine as it is on the hedgehog of England.

RHYNCHOTA.

CIMICIDAE.

Clinocoris (Cimex) lectularius, L.

I have seen specimens from many parts of Palestine, from the ports and the coastal plain and the hills, and the Jordan Valley (Tiberias, Dr. Herbert Torrance). All specimens examined are *C. lectularius*. It is interesting that this species can survive in a place with the high mean temperature of Tiberias. We have had great difficulty in destroying bugs by cyanide fumigation, owing to the bad construction of many houses, and in particular to leakage through tile roofs. We find it best to fumigate at night, when the wind is generally less than by day, and when the convection currents formed by the sun beating on the roof are absent. Several local practitioners inform me that the bed-bug is one of the foreign bodies found most commonly in the human ear in Palestine. In the villages near Ramallah it is held that the presence of a bulb of Mediterranean squill (*Urginea maritima*) in a room will cause the death of any bugs there may be. If therefore one sees one of these bulbs in a village guest-room, one must expect an unusually disturbed night, for no one would trouble to bring the bulb from the fields unless the bugs were particularly troublesome, and it is no manner of use when it has been brought in.

Cacodmus villosus, Stål.

About a dozen on a specimen of *Pipistrellus kuhli*, Beisan, June; a single individual on a specimen of the same bat, Jericho, February. In each case the insects were taken on bats shot flying at dusk.

SIPHUNCULATA.

PEDICULIDAE.

Pediculus humanus, L.

Body lice (*P.h. humanus*) and head lice (*P.h. capitis*) are both apparently common, but I regret that I have no knowledge of their relative frequency. Typhus is fairly common in winter and spring. Relapsing fever is rare, though it was common among Egyptian labourers in Palestine during and after the war; we have seen several sporadic cases in natives of the country who had not travelled or been exposed to any source of infection which could be traced. I have never actually seen *Phthirus pubis*, though I am informed that it is common.

GYROFIDAE.

Gliricola porcelli, L.

Jerusalem, on guinea-pigs; the laboratory stock of these animals originated in Cairo.

HAEMATOPINIDAE.

Linognathus stenopsis, Burm.

Jerusalem, 5th July (on goat).

Polyplax spinulosus, Burm.

On *Mus rattus*, Jerusalem, October, common on some individuals, apparently absent from others.

MALLOPHAGA.

TRICHODECTIDAE.

Trichodectes ciliatus, Gerv.

Jerusalem, 5th July (on goat).

MENOPONIDAE.

Trinotum anserinum, F.

Artuf, 26th March, on goose.

ARACHNIDA.

IXODIDAE.

It seems probable that our collection of ticks, which is due largely to the energy of Mr. Gilbert, Veterinary Inspector, Jaffa, is fairly representative of those which occur on domestic animals. Much remains to be done with regard to the ticks of Reptiles. It was suggested many years ago that a considerable mortality among field mice (*Microtus*) was caused by a "tick which was settling on the eye-lids and causing blindness." So far as I know, no evidence was produced to support this ingenious hypothesis, and I know of none that has been accumulated since; it is unfortunate that it has been allowed to appear in print more than once, because it is now an article of faith with many people.

Haemaphysalis cinnabarina, Koch.

On cow, Jaffa; once only.

Haemaphysalis leachi, Audouin.

On hedgehog (*Erinaceus roumanicus sacer*), Jerusalem (common).

Rhipicephalus sanguineus, Latr.

On dog (the normal host), goat, cattle, hedgehog (*E. r. sacer*), horse, donkey, sheep, camel; localities: Haifa, Jaffa, Braja, Qazazeh, Jerusalem, Nazareth, Jericho, i.e. in all parts of the country, coast, hills and Jordan Valley. This is a very abundant pest of the dog all through the summer. It appeared to be absent from Amman, Transjordan, in August and September.

Boophilus annulatus, Say.

On cattle, camel, goat, horse, mule, donkey, sheep; localities: Ekron, Sarona, Qazazeh, Jaffa, Haifa, Nazareth, Beisan, *i.e.* all parts of the country.

Hyalomma syriacum.

On lizard (*Agama*), at Nazareth; on land tortoise (*Testudo*), Carmel (Bodkin),

Hyalomma aegyptium, L.

On hedgehogs (*Erinaceus auritus* and *E. roumanicus sacer*), cattle, horse, donkey, mule, goat, camel, and *Agama*, once also attached to man below the knee; localities: Amman, Nablus, Nazareth, Hebron, Jerusalem, Sarona, Haifa, Jericho, *i.e.* generally distributed.

Argas persicus, Oken.

Tiberias, June (Bodkin); Kinereth, Yemma, Benshamen (Bodenheimer). No doubt common on domestic fowls, in all parts of the country.

SARCOPTIDAE.

Sarcoptes scabiei var. *canis*.

From dog, Jerusalem. *S. s.* var. *hominis*, Hering, no doubt occurs, as scabies is a common disease, but I have never actually seen a specimen of the mite in Palestine.

SCORPIONIDAE.

I have never seen a case of scorpion-sting, and I do not believe that the sting of the Palestine species ever results in death. The following are my records.

Buthus quinquestriatus, H. & E.

Jerusalem: Wadi Kelt; Jericho. A common species.

Buthus judaicus, E. Sim.

Haifa; Jerusalem.

Buthus bicolor, H. & E.

Nazareth.

Nebo heirochonticus, E. Sim.

Jericho; Haifa.

Heterometrus maurus, L.

Jerusalem; Jericho.

SOLIFUGAE.

These creatures are locally reputed to be very deadly; I therefore include them, though they are I believe harmless, because they are very often sent to the entomologist for identification.

Paragaleodes scalaris, Koch.

Wadi Kelt.

Galeodes sp. (near *orientalis*).

Amman, Transjordania.

Rhagodes melanus, Ol.

Tel el Milh, Beersheba.

IV. AGRICULTURAL PESTS.

DIPTERA.

CECIDOMYIIDAE.

Perrisia oleae, F. Lw.

This species is extremely common all over the country, wherever the olive grows, but I have never seen the crop seriously reduced by it. The larva lives in the leaf and makes a slight and indefinite thickening, which is visible on both the upper and lower

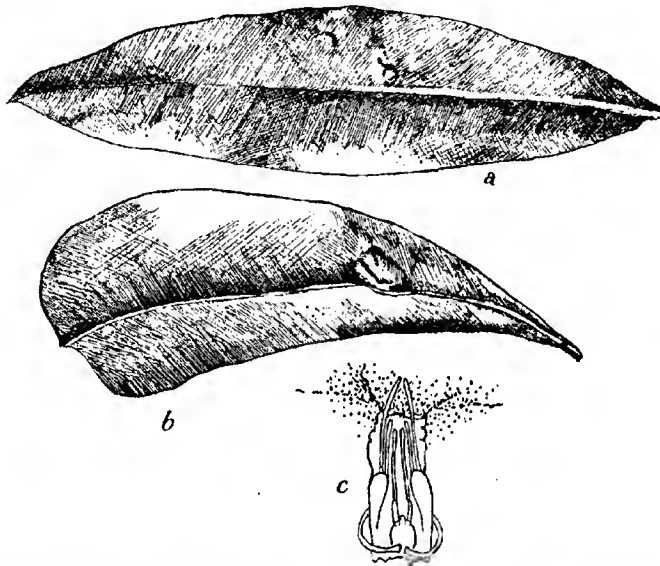


Fig. 8. *Perrisia oleae*: a, b, leaves of olive (*Olea europaea*) showing characteristic gall; c, empty pupa shell left projecting from lower surface of leaf after emergence.

surface (fig. 8, a, b). One frequently finds as many as three galls on one leaf. The empty pupa shell is left protruding from the lower surface of the leaf after the fly has emerged (fig. 8, c). The colours of the soft parts of the female fly during life are:—Eyes black, first abdominal segment and ovipositor honey-yellow, rest of abdomen cherry red.

Lasioptera kiefferiana, Del Guercio.

Mikiola sp.

These two minute midges were bred from a lot of fresh olive fruits from Latron, September and October, 1922. The fruits were heavily infested with *Dacus oleae* and it seems possible that the Cecidomyiids are saprophytic on the olives, after the *Dacus* has attacked them. On the other hand Del Guercio, whose paper I have only consulted in summaries, regarded *L. kiefferiana* as a pest of both the vegetative and reproductive organs of the olive.

TIPULIDAE.

Tipula oleracea, L.

Caesarea, 26th February.

I have no knowledge of this species as a pest.

TRYPETIDAE.

Ceratitis capitata, Wied.

The Mediterranean fruit-fly was a serious pest of apricots and a less serious pest of nectarines at Nahr, Kabri and other villages north of Akka in June 1921. It also attacks oranges in the Jaffa area, and I have found females sitting on olive leaves in November, but never actually bred the species from olives. Its prevalence in the district north of Akka is doubtless due to the great variety of fruit-trees which grow in that rich and well-watered plain. It appears that nothing can be done unless the owners of trees will agree to cultivate only one or two kinds of fruit in the lands of each village; in this way the continuity of generations of the fly will be broken.

In the Jaffa area, particularly at the colony of Petach Tikvah, care is now devoted to grading and packing oranges, and diseased fruits are collected and used as a source of citrates. In this way one hopes that many fruits containing *Ceratitis* will find their way to the factory, instead of remaining in the orange-garden; this should reduce the numbers of *Ceratitis*.

Dacus oleae, Gmel.

Lydda, Latron, Jerusalem; doubtless generally distributed.

Many methods are employed in Palestine for preserving olives, and many different grades of olives, both black and green, result. The essential of all the methods is that the fresh fruit, either entire, or scratched with a knife, or rolled between boards, or after steeping in water for some days, is packed with salt or soaked in brine; after a period which varies in different households the olives are packed into jars, flavoured with lemon juice and chillies, and covered with olive oil. There is a considerable export of these pickled olives to Egypt. At some stage during these processes the larvae of *D. oleae* die. This I have proved by keeping many kilograms of pickled olives in the laboratory for many months spread out on sand in cages; no *Dacus* emerged from any of the samples, though the insect had been abundant at the time of the olive harvest.

DROSOPHILIDAE.

Drosophila funebris, F.

I have bred this fly from ordinary salted olives bought in the Jerusalem market, but I have never found it common. The species was determined by Sturtevant.

RHYNCHOTA.

APHIDIDAE.

Brevicoryne brassicae, L.

On cabbage, Rishon Le Zion, Jaffa, Nov. 1921. A large field of cabbages was ruined by this insect.

Moslem gardeners in Jerusalem hang blue beads on the rose bushes to avert evil eye and Aphids.

COCCIDAE.

Most of the species which I have taken have been already recorded by Hall, but the following records have not been published.

Chrysomphalus aonidum, L. (*ficus*, Ashm.).

At present occurs only in North Palestine, for instance at Haifa, Beisan, Saffourieh near Nazareth (also at Beirut, Syria).

In the places in which it is found it is a grave pest of orange and lemon trees; an energetic fumigation campaign is conducted by the Agricultural Entomologist to prevent, if possible, its spread to the Jaffa area. Its introduction into the extensive orange gardens round Jaffa would be a calamity for Palestine, for the trees are planted so closely that fumigation would be extremely difficult, if not impossible. It is also found on olives at Jerusalem.

Aspidiotus britannicus, Newst.

Jerusalem, on olive.

Lecanium hesperidum, L.
On *Schinus molle*, Jerusalem.

Crypthemichionaspis africana, Newst.
Bark of *Populus euphratica*, River Jordan, near Jericho. (First record outside Egypt.)

Euphilippia olivina, Berl. & Silv.
Rare on olive leaves, Jerusalem.

Parlatoria oleae, Colvée (*calianthina*, Berl. & Leon.).
Garden rose, Nablus.

Chionaspis striata, Newst.
Jerusalem, abundant on *Cupressus*, in gardens.

Pseudococcus citri, Risso.
Under fig bark, Jerusalem.

Icerya purchasi, Mask.
I have found this scale on *Eucalyptus* in Jerusalem.

PSYLLIDAE.

Trioxa buxtoni, Laing.

This species is described by Laing on page 247. It is a very serious pest of the fig tree (*Ficus carica*) at Jericho; the leaf illustrated (fig. 9) is only slightly infested.



Fig. 9. •Leaf of *Ficus carica* showing a light infestation by *Trioxa buxtoni*, Laing.

LEPIDOPTERA.

Pieris brassicae, L.

Abundant all over the country on cabbage and cauliflower; a serious pest. I have bred it also from larvae found on *Capparis spinosa* at Haifa, May 1921. The Capparidaceae and Cruciferae are regarded by botanists as nearly related, so it is not perhaps very remarkable to find *P. brassicae* on this food-plant. *Capparis* is of course the regular food-plant of many PIERIDAE, e.g. *Belenois* and *Teracolus*; possibly there is a chemical similarity between it and the Cruciferae. I have also bred *P. brassicae* from *Tropaeolum majus*, growing in a garden at Tabgha. It is parasitized by *Apanteles glomeratus* in Palestine.

Pieris rapae, L.

Occurs commonly.

Danaus chrysippus, L.

The usual food-plant is *Calotropis procera* (Haifa and Jericho), but at Tantura I found larvae on a cultivated Asclepiad from the seed-vessels of which the villagers were extracting "cotton."

Virachola livia, Klug.

In many parts of the Jaffa area hedges of *Acacia farnesiana* have been planted; they are haunted by great numbers of *V. livia*. The egg is laid on the pod, more often than not on the base. One, two or even three larvae may be found in a single pod, and pupation takes place in the larval burrow or in soil. Larvae may also be found commonly in pomegranates, and as Mr. I. Aharoni informs me, in tomatoes. *Acacia farnesiana* grows as an introduced plant in many parts of Palestine; there is a tree in the Birket Mamilla cemetery in Jerusalem, and I have bred *V. livia* from this tree. I have also noticed the tree at Jericho, Beisan and Haifa, but in these places I have failed to find any trace of *V. livia*. Probably therefore the butterfly is a recent introduction from Egypt to the Jaffa area. I am told by Mr. P. P. Graves that, so far as he knows, it has not been recorded from Palestine before, though it occurred at Beirut in 1910; he suggests that it is spread by commerce, in fruits of pomegranate and pods of *A. farnesiana*, which are used by tanners.

Theretra alecto, L.

Nazareth, 23rd May.

Zeuzera pyrina, L. (*aesculi*, L.).

Jerusalem, July. A common insect and a serious pest of fruit-trees.

Diloba caeruleocephala, L.

The larva is common on almond trees in April, in Jerusalem.

Earias insulana, Boisdu.

Bred from cotton bolls, from Akka, 22nd April.

Nephopteryx mendacella, Stgr.

Jerusalem, bred from cones of *Pinus halepensis*.

Platyedra gossypiella, Saund.

I have bred the pink bollworm from cotton bolls from Haifa and Akka. I have made no search for it elsewhere.

Anarsia acaciae Wals.

December, Jaffa. Bred from pods of *Acacia farnesiana*.

Plutella maculipennis, Curt.

Akka, 10th Nov.; Jerusalem, 22nd April.

COLEOPTERA.

COCCINELLIDAE.

Epilachna chrysomelina, F. Beisan, 10th June. Larvae very destructive to cucumber leaves.

MELOLONTHIDAE.

Haplidia chaifensis, Kraatz.

This insect is extremely abundant at Haifa in May, swarming at dusk over hedges and trees of all kinds, and copulating on the leaves. The larva is, I believe, unknown, but if it attacks any useful plant it must be a very grave pest.

BUPRESTIDAE.

Capnodis carbonaria, Klug.

Haifa; Akka and Kabri; Jerusalem.

In 1921 it first appeared on 25th May in Haifa, and became common by 28th May; by the end of June it was rare, but a few individuals were seen in July and August. This insect is an abundant pest of the almond, and I think also of the apricot, and may easily be collected by hand, as it sits always on the lower part of the almond trunk. In my breeding experience with *Cerambyx dux* I have never actually obtained this species from trunks of almond. I do not know which of the two is the greater menace to the almond industry in Palestine.

Chalcophora stigmatica, Dalm.

Jerusalem; Wadi Kabala, May.

Aurigena chlorana, C. & G.

Yessod ha Maaleh, Heleh, 20th April; Jerusalem, 16th April.

These two species are very common on almond trees in April and May, and I have little doubt that the larva lives in the trunks, and that they are serious pests.

ANOBIIDAE.

Sitodrepa panicea, L.

In dog biscuit, Jerusalem.

TENEBRIONIDAE.

Tribolium castaneum, Hbst.

In dog biscuit, Jerusalem.

Tenebrio obscurus, F.

St. George's Cathedral, Jerusalem, March-May.

Bred from pigeons' dung in the belfry.

CERAMBYCIDAE.

Cerambyx dux, Fald.

Haifa; Akka; Jerusalem; abundant.

Most of my observations were made at Haifa, in 1921. The insect was first seen on 21st May, and by the end of the month was abundant. By 19th June it was no longer common. The beetles were generally found sitting on almond trunks within three feet of the ground, occasionally as high as six feet. They run actively on the trunk and drop to the ground when alarmed; when picked up they emit

the jarring sound made by so many Longicorns. They are rarely seen flying. On 8th February I dug up an almond tree in Jerusalem which was riddled with borings of this species. Under the bark of the subterranean part of the stem we found seven adults, hard and ready to emerge from their cells. The trunk was divided into lengths of one foot, and between 1st and 17th May following *C. dux* emerged from each of the three lengths. In September I treated another log in a similar way; one individual emerged, in a cool laboratory, in October, the rest between 22nd and 29th May; the log was stored in lengths of one foot, and from the length next above the ground I got five beetles, from the one above it, one, from the third two, and from the fourth none. This agrees with what one observes in nature, that the damage is worst near ground level. For keeping the logs I used cases made according to Beeson's method; we employed 4-gallon petrol tins, with a tight-fitting lid on which was a ventilator with a cap, and also an aperture to take the mouth of a large test-tube, passed through a cork. A small retort would be better than a test-tube.

Trees which are bored by *Cerambyx* and *Capnodis* very rapidly cease to bear almonds, and become secondarily infested with a host of SCOLYTIDAE, termites and other things. The almond crop is an important one in Palestine (in 1920 the crop returns of the Revenue Department totalled 238,000 kilogrammes of almonds; in 1921 436,516 kilos.), and is perhaps menaced by more pests than any other crop in the country.

There is much talk of enlarging the area under almonds, but I do not think this can be wisely done unless the farmers will attend to these boring beetles. Nearly every full-grown tree in Palestine harbours them, but I am convinced that they could be easily controlled during their short season by hand-picking.

CLYTRIDAE.

Gynandrophthalma viridana, Latr.

Very destructive to the leaves of cultivated roses, Jerusalem.

CURCULIONIDAE.

Apion malvae, F.

Beaten in numbers from olive trees, at Haifa, July.

ORTHOPTERA.

I have made a somewhat extensive collection of these insects; all the material has been identified by Mr. B. P. Uvarov, of the Imperial Bureau of Entomology, and the specimens are in the British Museum. I understand that a full list of the species and some oecological notes will shortly appear in the Bull. Soc. Ent. d'Egypte.

The following species are the principal ones of economic importance, though many others appear to do occasional damage to young crops.

BLATTIDAE.

Supella supellectilium, Serv.

A cosmopolitan domestic species; found in Haifa, November.

Blatta orientalis, L.

Jerusalem, November.

GRYLLIDAE.

Gryllus domesticus, L.

Common in houses, probably in all parts of the country. I have specimens from Haifa and Beisan.

Gryllotalpa gryllotalpa, L.

Riyak, Syria, 29th March; Caesarea, 22nd March; Jerusalem, 6th May; Beisan, 16th June.

Common, and a serious pest particularly in market gardens. The cultivators flood out mole-crickets and kill them by stamping on them.

TETTIGONIDAE.

Decticus albifrons, F.

Beisan, 15th June; Dhahariyeh, Hebron, 11th May. Abundant in many places, but I have never seen it in great numbers.

ACRIDIDAE.

Docostaurus maroccanus, Thunb.

Wadi Kelt, 21st May; Beersheba, 12th May; Zorah, 22nd May.

An abundant species, at any rate in the south and the Jordan Valley. We have no knowledge of it as a pest in Palestine.

Docostaurus anatolicus, Krauss.

Nazareth, 30th June; Nablus, 1st June; Akka, 29th June; Tulkeram, 12th June; Kakon, 11th June.

Probably an occasional pest.

Calliptamus italicus, L.

Nazareth, 30th June; Akka, 9th June; Amman, Transjordan, 21st August; Wadi Biar, Bethlehem, 17th October; Beisan, 25th July; Tulkeram, 14th June; Kakon, 11th June; Nahalal, 12th November; Haifa, 10th November.

This species is abundant in low grounds round the edge of cultivation, for instance in the Beersheba plains and in the valleys which run down into the Jordan depression. I have no knowledge of it as a definite pest.

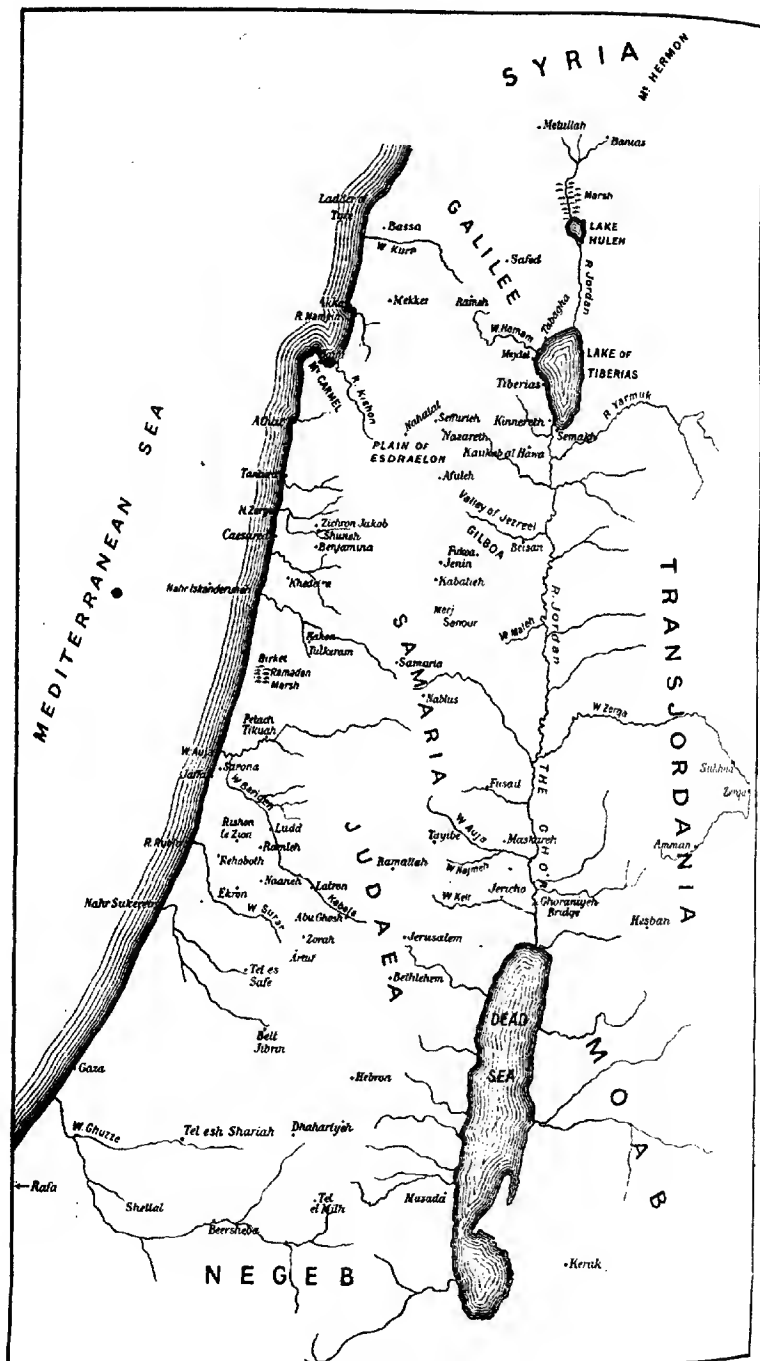
Anacridium aegyptium, L.*Locusta migratoria* ph. *danica*, L.

These species are common enough, and my records are too numerous to quote. It is interesting to note that only the harmless solitary phase of *L. migratoria* has been found and not the swarming one, which seems to indicate that conditions in Palestine are not favourable for producing mass swarms. Mr. Aharoni tells me that neither is a serious pest. It is *Schistocerca gregaria*, Forsk. (*peregrina*, Ol.) that periodically does such damage in Palestine; the last incursion was in 1916 and combined with the war to bring large parts of the country to the verge of starvation. McKillop and Gough state that *S. gregaria* "is distributed widely throughout South-Western Asia and North Africa, breeding normally in Palestine, Arabia and the Sahara Oases." I have never taken the species in Palestine during three summers' collecting, and I venture to doubt whether it breeds except in the years following incursions.

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MAP OF PALESTINE.

PUPAE OF SOME PALESTINIAN CULICINES.

By OSCAR THEODOR.

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In connection with the study of Anopheline pupae with Dr. P. A. Buxton, I extended my comparisons to the Culicine pupae accessible to us, in the first place to discover their differences from Anopheline pupae, and in the second to bring the Culicine pupae themselves into a system. As with the Anopheline pupae, I limited

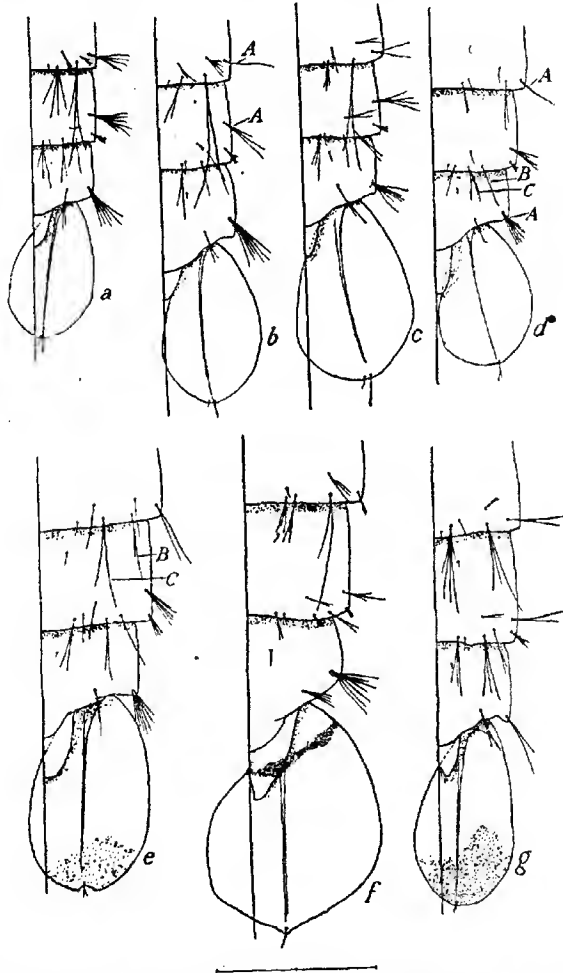


Fig. 1. Dorsum of 6th-8th abdominal segments of pupa of: (a) *Culex pipiens*, (b) *C. mimeticus*, (c) *C. laticinctus*, (d) *Ochleroratus caspius*, (e) *Theobaldia annulata*, (f) *T. longiareolata*, (g) *Culicella morsitans*.

my comparisons to the trumpets and the chaetotaxy of the abdomen, especially of the last three abdominal segments. Of about 21 species of Culicines known from Palestine, pupae of the following 12 were available: *Uranotaenia unguiculata* (one pelt in rather bad condition), *Culex tipuliformis* (one pupa), *C. pipiens*, *C. hortensis*, *C. mimeticus*, *C. laticinctus*, *C. perexiguus*, *Theobaldia longiareolata*, *T. annulata*, *Culicella morsitans*, *Stegomyia fasciata* and *Ochlerotatus caspius* (several pelts of each). All of them are at once distinguishable from the Anopheline pupa by several characters. The large lateral seta (A) in *Anopheles* is a single spine on segments 3 to 7, while in the Culicines it is a long, often branched seta (fig. 1, b, d.). Moreover in Anophelines it is situated at the extreme posterior angle of the segment, in Culicines at a point anterior to the angle; in all of our Anophelines there is a small seta on the blade of the paddle, which is absent in all the Culicines known to us from skins or figures. The trumpets both in Anophelines and Culicines show considerable specific differences, but at any rate in Palestinian species the index (meatus: total length) is below 0.5:1 in Anophelines, and above 0.6:1 in Culicines.

The pupal trumpets of all the species of *Culex* known to me and of *Uranotaenia unguiculata* have a series of transverse folds, in some of them beginning at the base and covering half the length of the trumpet, in others only forming a band, about a sixth of the length of the trumpet and not extending quite round it. Of eight *Culex* trumpets, figured by Macfie and Ingram, only one (*C. macfiei*, Edw.) lacks these folds. They are also absent in one of the two species of *Uranotaenia* figured. On the other hand, none of the Culicines belonging to other genera known to me have this folding, again agreeing with the figures of Ingram and Macfie. Perhaps we can assume that this series of folds forms a character of the genera *Culex* and *Uranotaenia*, an assumption which of course requires confirmation by a study of more material than is available to me.

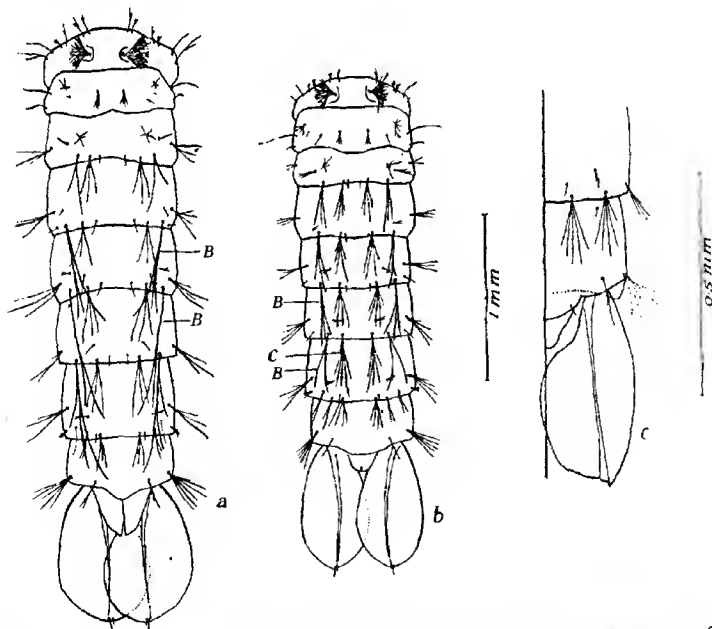


Fig. 2. Dorsum of 6th-8th abdominal segments of pupa of: (a) *Culex hortensis*, (b) *C. perexiguus*, (c) *Uranotaenia unguiculata*.

The pupa of *Uranotaenia* (fig. 2, c) differs sharply from that of all our other Culicines by the peculiar shape of the paddles, also by the sharp basal prolongation of the mouth of the trumpet, and the presence of a small seta on the terminal process of the 8th segment, overlying the base of the paddle. This seta I have found in no other genus; Ingram and Macfie figure it for *U. balfouri* and *inornata*, so perhaps it is a generic character.

The separation of the other Culicines is not easy, because the abdominal setae vary considerably in length and position in each species and one has to be careful not to make too fine distinctions.

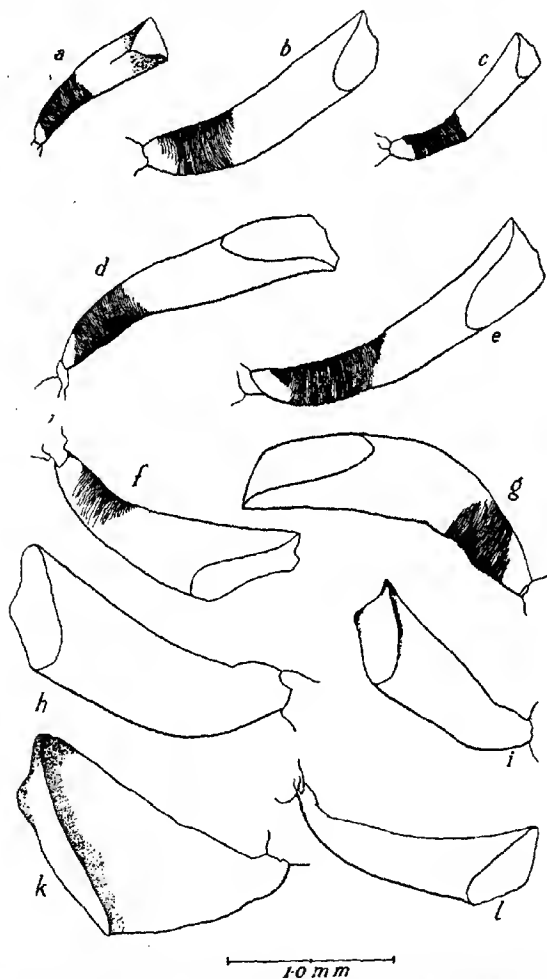


Fig. 3. Pupal trumpets of: (a) *Uranotaenia unguiculata*, (b) *Culex pipiens*, (c) *C. peregrinus*, (d) *C. hortensis*, (e) *C. mimeticus*, (f) *C. laticinctus*, (g) *C. tipuliformis*, (h) *Theobaldia annulata*, (i) *Ochlerotatus caspius*, (k) *Theobaldia longiareolata*, (l) *Culicella morsitans*.

Culex perexiguus (fig. 2, b) is easily determined by the short setae B and C; the differentiations of the other five species of the genus is more difficult, but can be arrived at by a combination of trumpet and seta characters, as shown in the key and the figures.

C. tipuliformis could not be included in the key, because the only pupa available is damaged. It seems to have short setae B and C, like *C. perexiguus*, and the seta A with several branches. The proportions of its trumpet are about the same as in *C. laticinctus*, but the trumpet is rather parallel-sided, not broadening towards the apex, as in *laticinctus* (fig. 3, f, g).

Theobaldia longiareolata is characterised by the broad trumpet (fig. 3, h) and the irregular pentagonal form of the paddle (fig. 1, f). While examining this species my attention was drawn to a peculiar feature, a black transverse band across the paddle, near the base. Sometimes it was present on both sides, sometimes on one side only, and in 60 per cent. of the specimens examined it was absent. Later I found this band in some of the specimens of almost every species of Culicines and Anophelines, and found it connected with a fine canal (alimentary canal?), which opened under the base of the paddle and extended forward to the 2nd or 3rd abdominal segment. This canal, especially in the 8th segment, contains often a black mass, which is presumably faeces. A similar band is figured by Macfie and Ingram in the pupa of *Megarhinus brevipalpis*, Theo., but without any comment. I assume that it is a faecal coloration and mention it because it might very easily be mistaken for pigmentation and regarded as a specific character.

Theobaldia annulata and *Culicella morsitans* are very similar; both have a distally infuscated paddle (fig. 1, e, g), but in *Culicella* the paddle and trumpets are more slender, there is no terminal concavity of the paddle, and the lateral setae are simple or sometimes bifid.

Ochlerotatus caspius and *Stegomyia fasciata* both have a slight secondary feathering of the lateral seta (A) on the 8th segment. This seta is shorter than the segment in *Ochlerotatus* and has 6-8 branches (fig. 1, d), while in *Stegomyia* it has 4-5 stouter branches, longer than the segment.

For the sake of uniformity with the work of Macfie and Ingram the following measurements and ratios are given. Their trumpet index often fails to call attention to important differences in shape, and perhaps the proportion of the total length (=1) to the width at the end of the meatus, measured vertically to the longer side, will help to designate the general appearance of the trumpet more accurately. One must, of course, be careful not to use flattened specimens for measuring.

Species.	Paddles.		Trumpets.		
	Length mm.	Length : breadth (=1)	Length mm.	Width : length (=1)	Meatus : length (=1)
<i>Culex pipiens</i> ...	0.83-0.90	1.40-1.50 : 1	0.77	0.20 : 1	0.75-0.8 : 1
<i>C. hortensis</i> ...	0.90-1	1.35-1.40 : 1	0.66	0.20 : 1	0.65 : 1
<i>C. mimeticus</i> ...	1.00	1.45 : 1	0.90	0.16 : 1	0.63 : 1
<i>C. laticinctus</i> ...	0.90	1.30 : 1	0.74	0.26 : 1	0.70 : 1
<i>C. tipuliformis</i> ...	0.90	1.40 : 1	0.85	0.23 : 1	0.70 : 1
<i>C. perexiguus</i> ...	0.70-0.80	1.60-1.65 : 1	0.50-0.65	0.14 : 1	0.80-0.85 : 1
<i>Uran. unguiculata</i>	0.60	1.70 : 1	0.42	0.24 : 1	0.78 : 1
<i>Theo. longiareolata</i>	1.30	1.12 : 1	0.75	0.37 : 1	0.625 : 1
<i>Theo. annulata</i> ...	1.20	1.50 : 1	0.75-0.83	0.325 : 1	0.75-0.8 : 1
<i>Culicella morsitans</i>	1.00-1.15	1.60 : 1	0.66-0.74	0.30 : 1	0.76 : 1
<i>Stegom. fasciata</i> ...	0.90	1.20 : 1	0.57	0.34 : 1	0.60 : 1
<i>Ochlerot. caspius</i>	0.90-0.95	1.20-1.25 : 1	0.57	0.31 : 1	0.80 : 1

Key to Culicine Pupae of Palestine.

1. Trumpet with many transverse folds near base 2
Trumpet without such folds 7
2. Mouth of trumpet with sharply angulated basal prolongation. Paddle
"knife-like," inner margin deeply excavated towards base (fig. 2, c)
Uranotaenia unguiculata
Mouth of trumpet rounded towards base; paddle rounded (*Culex*) .. 3
3. Seta B and C of segments 4-6 thin, as long as one segment or a little
longer (fig. 2, b) *C. perexiguus*
Seta B and C of segments 4-6 thicker and as long as 1½-2 segments
(fig. 2, a) 4
4. Large lateral seta (A) of segments 3-6 single, sometimes bifid (fig. 1, b) ..
C. mimeticus
Seta A of segments 3-6 with 2-6 branches 5
5. Trumpet short and broad at apex, ratio (width : length) 0.26 : 1 (fig. 3, f) ..
C. laticinctus
Trumpet longer, ratio index 0.2 : 1
6. Trumpet quite parallel-sided; seta A of 3rd to 8th segments with 3-6
branches (fig. 3, b) *C. pipiens*
Trumpet broadening towards apex; seta A of 3rd to 8th segments with
2-3, rarely 4 branches (fig. 3, d) *C. hortensis*
7. Trumpet short and wide, meatus equal to width of mouth (fig. 3, h);
paddle as broad as long, irregularly pentagonal (fig. 1, f)
Theobaldia longiareolata
Trumpet tubular; paddle longer, more evenly elliptical 8
8. Paddle with dark distal cloud; submedian seta (c) of 6th segment nearly
or quite one segment long 9
Paddle without such mark; seta c of 6th segment half a segment long .. 10
9. Terminal seta of paddle in a concavity; seta A of segments 6-8 with 3-5
branches (fig. 1, e) *Theobaldia annulata*
No terminal concavity; seta A of segments 6-8 simple or bifid (fig. 1, g)
Culicella morsitans
10. Seta A of 8th segment with 6-8 branches, shorter than the segment;
terminal seta of paddle sometimes bifid trifid, about a sixth of the
length of the paddle (fig. 1, d) *Ochlerotatus caspius*
Seta A of 8th segment with 4-6 branches, longer than the segment;
terminal seta of paddle simple, about a third of the paddle
Stegomyia fasciata

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st July and 30th September, 1923, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. T. J. ANDERSON, Government Entomologist :—1 Flea from Porcupine and 1 species of Coccidae on Coffee ; from Kenya Colony.

ASTRAKHAN ENTOMOLOGICAL SECTION :—72 Chalcididae ; from South East Russia.

Mr. T. V. RAMAKRISHNA AYYAR, Assistant Entomologist :—469 Hymenoptera ; from South India.

Mr. N. BARANOFF :—6 Diptera and 3 Hymenoptera ; from Serbia.

Mr. P. J. BARRAUD :—3 Chalcids and 73 Coleoptera ; from Punjab, India.

Mr. C. F. C. BEESON, Forest Zoologist :—22 Weevils ; from United Provinces, India.

Mr. G. E. BODKIN, Agricultural Entomologist, Department of Agriculture :—20 Siphonaptera, 7 Psychodidae, 12 Hymenoptera, 34 Coleoptera, 10 Rhynchota, 2 Orthoptera, 4 Myrmeleionidae, and 15 Ticks ; from Palestine.

BOMBAY NATURAL HISTORY SOCIETY (Collected by Mr. F. T. Mitchell) :—14 Diptera, 2 Hymenoptera, 5 Coleoptera, 2 Lepidopterous larvae, 4 Rhynchota, 10 Orthoptera, 2 Mayflies, and 2 *Chrysopa* ; from India.

Dr. G. BONDAR :—279 Coleoptera ; from Brazil.

Dr. P. A. BUXTON :—5 Tabanidae, 11 other Diptera, 43 Hymenoptera, 70 Coleoptera, 511 Lepidoptera, and 106 Orthoptera ; from Palestine.

Mr. L. D. CLEARE, Junr., Government Economic Biologist :—8 Culicidae, 2 Psychodidae, 300 Parasitic Hymenoptera, 2 other Hymenoptera, 5 Lepidoptera, and 14 Thysanoptera ; from British Guiana.

Mr. G. H. CORBETT, Government Entomologist :—55 Diptera and 10 pupa-cases, 117 Coleoptera, 120 Lepidoptera, and 69 Rhynchota ; from the Federated Malay States.

Mr. M. T. DAWE :—133 Ticks ; from Sierra Leone.

Mr. D. D'EMMERZ DE CHARMOY :—21 Formicidae and 2 Coleoptera ; from Mauritius.

DIVISION OF ENTOMOLOGY, Pretoria :—54 Diptera and 5 pupa-cases, 499 Hymenoptera, 139 Coleoptera, 5 Rhynchota, and 88 Orthoptera ; from South Africa.

CAPT. C. F. DIXON-JOHNSON :—1 Species of Coccidae on Orange ; from Spain.

Messrs. ELDERS & FYFFES, Ltd. :—Bananas infested with Moth larvae and 6 Moths ; from the Canary Islands.

Mr. J. H. J. FARQUHAR :—6 Tabanidae, 8 *Glossina*, and 2 Coleoptera ; from Nigeria.

Mr. D. T. FULLAWAY :—56 Coccinellidae ; from Hawaii.

Mr. F. D. GOLDING :—16 Diptera, 24 Coleoptera, 19 Lepidoptera, 11 Rhynchota, 12 Orthoptera, and 2 Odonata ; from Southern Nigeria.

Mr. C. C. GOWDEY, Government Entomologist :—2 *Tabanus*, 24 other Diptera, 33 Hymenoptera, 43 Coleoptera, 86 Lepidoptera, 3 Species of Coccidae, and 22 other Rhynchota ; from Jamaica.

Mr. H. HARGREAVES, Government Entomologist :—23 Diptera, 95 Coleoptera, 6 Lepidoptera, and 9 Rhynchota ; from Uganda.

Mr. G. F. HILL :—2 Isoptera ; from Australia.

Major R. W. G. HINGSTON :—8 Hymenoptera and 4 Lepidoptera ; from Iraq.

Mr. M. AFZAL HUSSAIN, Government Entomologist :—91 Diptera and 9 pupa-cases, and 71 Orthoptera ; from Punjab, India.

Mr. J. C. HUTSON :—8 Pyralid Moths ; from Ceylon.

Rev. NEVILLE JONES :—116 Coleoptera ; from Southern Rhodesia.

Dr. H. H. KARNY :—3 Micro-lepidoptera ; from Java.

Dr. W. A. LAMBORN :—20 Culicidae and 20 Lepidoptera ; from Nyasaland.

Mr. A. H. LEES :—1 Moth : from New Zealand.

Mr. A. LOVERIDGE :—11 Culicidae, 88 *Glossina*, 6 *Glossina* puparia, 81 Tabanidae, 43 Hippoboscidae, 3 *Auckmeromyia*, 3 *Cordylobia*, 249 other Diptera, 3 Dipterous pupa-cases, 69 Oestrid larvae, 250 Formicidae, 417 other Hymenoptera and 6 early stages, 8 Coleopterous early stages, 30 Lepidopterous larvae, 3 Lepidopterous larvae and their parasites, a number of Lepidopterous eggs, 3 Isoptera, 116 Orthoptera, 4 Hemimeridae, 50 Anoplura, 300 Mallophaga, 7 Planipennia, 4 Neuropterous early stages, 15 Odonata and 2 nymphs, 2 Spiders, and a number of Mites ; from Tanganyika Territory.

Mr. E. E. LOWE, Leicester Museum and Art Gallery :—5 Coleopterous larvae ; from Leicester.

MINISTRY OF AGRICULTURE, Cairo :—27 Orthoptera and 6 egg-cases ; from Egypt.

Mr. A. V. MITCHENER :—7 Hymenoptera and 26 Coleoptera ; from Canada.

NATAL MUSEUM :—250 Coleoptera and 250 Rhynchota ; from South Africa.

Mr. T. PARKER (Messrs. Murphy & Son) :—5 Weevils attacking Clover ; from Essex.

Mr. W. H. PATTERSON, Government Entomologist :—8 Hymenoptera, 8 Coleoptera, 4 Lepidoptera, 55 species of Coccidae, and 4 other Rhynchota ; from the Gold Coast.

Mr. V. PLOTNIKOV, Director, Entomological Station :—311 Orthoptera ; from Turkestan.

Assistant Prof. of Entomology (per Prof. H. Maxwell Lefroy), Poona :—2 Diptera and 61 Hymenoptera ; from India.

Mr. T. RAMACHANDRA RAO, Government Entomologist :—5 Coleoptera and 13 Lepidoptera ; from South India.

Mr. A. H. RITCHIE, Government Entomologist :—5 Hymenoptera, 210 Coleoptera, 42 Rhynchota, and 6 Trombididae ; from Tanganyika Territory.

Mr. M. ALI SHIRAZEE :—5 Coleopterous larvae and 8 Pentatomid Bugs ; from Persia.

Mr. H. W. SIMMONDS, Government Entomologist :—4 Culicidae, 3 Scolytidae, 2 species of Coccidae, and 32 other Rhynchota ; from Fiji Islands.

Mr. H. P. THOMASSET :—131 Diptera, 60 Hymenoptera, and 11 Rhynchota ; from Natal.

Mr. J. R. LE B. TOMLIN :—9 Lepidopterous larvae ; from Guernsey.

Dr. O. THEODOR, Malaria Research Unit, Haifa :—22 Culicidae ; from Palestine.

Mr. R. VEITCH :—135 Diptera, 2 Hymenoptera, 3 Coleoptera, 7 Lepidoptera, and 3 Rhynchota ; from Fiji Islands.

WELLCOME TROPICAL RESEARCH LABORATORIES, Khartoum :—9 Chalcididae and 242 Coleoptera ; from British Sudan.

Mr. D. S. WILKINSON, Government Entomologist :—9 Diptera, 47 Coleoptera,
6 Micro-lepidoptera, and 17 Rhynchota ; from Cyprus.

Mr. H. WILKINSON, Assistant Entomologist :—263 Coleoptera ; from Uganda.

Mr. G. N. WOLCOTT :—21 Coleoptera and 3 Rhynchota ; from Porto Rico.

Mr. R. C. WOOD :—14 Culicidae, 17 Tabanidae, 6 Simuliidae, 83 other Diptera,
31 Hymenoptera, 429 Coleoptera, 12 Lepidoptera, 3 Cimicidae, 7 other Rhynchota,
5 Orthoptera, 3 Myrmelionidae, 2 *Chrysopa* nymphs, 11 Ticks, and 5 Spiders ; from
Nyasaland.

A SYNOPSIS OF THE ADULT MOSQUITOS OF THE AUSTRALASIAN REGION.

By F. W. EDWARDS.

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In two previous papers (Bull. Ent. Res. xii, p. 263, 1921 and Ind. Jl. Med. Res. x, pp. 249 and 430, 1922) the writer has published revisions of the mosquitos of the Palaearctic and Oriental regions, using for the classification of the genera certain small characters, chiefly in the thoracic chaetotaxy, which are applicable alike to both sexes. In the present revision of the Australasian species the same characters are applied.

Our knowledge of the mosquitos of this region is still rather incomplete, especially as regards the early stages, very few of the larvae having been described, although a good many of the species have been reared. The number of species at present known is also smaller than might be expected in view of the much larger Oriental fauna, so that it is probable that a good many species await discovery.

As regards Australia and New Guinea the greater part of our present knowledge is due to Dr. T. L. Bancroft and Messrs. G. F. Hill and F. H. Taylor, on whose collections this review is mainly based. To Mr. Hill especially the writer is indebted for ready assistance and the loan of the majority of Taylor's types from the Australian Institute of Tropical Medicine. Further valuable material has been received at different times from Lt.-Col. R. Alcock, F.R.S., Drs. J. H. Ashworth, F.R.S., S. L. Brug, A. G. Carment, J. B. Cleland, F. W. O'Connor, and E. W. Ferguson, and from Messrs. A. E. Brookes, J. W. Campbell, C. L. Edwards, T. R. Harris, D. Miller and R. Veitch.

In this revision all species endemic to the region are discussed, and also all other species which have been found on the mainland of Australia or Papua. In addition to these, a number of other Oriental species have been recorded from the Moluccas, Celebes and the Timor group, but not from further east. Of these I simply give the list, which will doubtless be increased by future collecting:—

- Anopheles* (*Anopheles*) *hyrcanus*, Pall. Celebes, Sunda Is.
- Anopheles* (*Anopheles*) *barbirostris*, v.d.W. Celebes, Buru, Ceram, Sumba, Timor.
- Anopheles* (*Anopheles*) *barbirostris*, var. *pallidus*, Swell. Ceram, Amboina.
- Anopheles* (*Anopheles*) *aitheni*, Theo., var. *insulae-florum*, Swell. Amboina.
- Anopheles* (*Myzomyia*) *vagus*, Dön. Celebes, Amboina, Sumba.
- Anopheles* (*Myzomyia*) *subpiculus*, Grassi. Celebes, Moluccas, Sumba.
- Anopheles* (*Myzomyia*) *ludlowi*, Theo. N. Celebes, Sunda Is.
- Anopheles* (*Myzomyia*) *minimus* var. *aconitus*, Dön. Sumba.
- Anopheles* (*Myzomyia*) *fuliginosus*, Giles. Sumba, Timor, Sunda Is.
- Anopheles* (*Myzomyia*) *maculatus*, Theo. Alor.
- Anopheles* (*Myzomyia*) *leucosphyrus*, Dön. N. Celebes.
- Anopheles* (*Myzomyia*) *kochi*, Theo. Celebes.
- Anopheles* (*Myzomyia*) *punctulatus* var. *tesselatus*, Theo. Celebes and Moluccas.
- Megarhinus* *amboinensis*, Dol. (*lewaldi*, Ludl.). Amboina.
- Aedes* (*Stegomyia*) *annandalei*, Theo. Buru.
- Aedes* (*Aedes*) *umbrosus*, Brug. Celebes.
- Aedes* (*Aedes*) *butteri*, Theo. Celebes, Ceram, Saparoea.
- Lutzia* *fuscana*, Wied. Celebes.
- Culex* *fuscocephalus*, Theo. Celebes, Timor.
- Culex* *malayi*, Leic. Timor.
- Culex* *castrensis*, Edw. Timor.
- Culex* *sinensis*, Theo. Celebes.

According to the researches of Swellengrebel and Rodenwaldt it would seem that the mosquito fauna of Celebes, the volcanic Sunda Is., and to a large extent of the Moluccas, has much more affinity with that of the Oriental region than with that of Australia and New Guinea; Wallace's line, therefore, does not hold for this group of insects.

As regards the general features of the fauna it may be remarked that the genera *Topomyia*, *Harpagomyia*, *Mimomyia*, *Orthopodomyia*, *Haemagogus*, *Heizmannia* and *Pardomyia*, and the subgenera *Leicesteria* and *Acalleoemyia*, all of which are represented in the Oriental region, are apparently absent; while some other genera and subgenera, particularly *Anopheles* and *Stegomyia*, are comparatively poor in species. The Pacific islands on the whole support an extremely poor mosquito fauna—in regard to species, though individuals are only too numerous. Even in New Zealand there are no representatives of any of the endemic American genera, such as *Sabethes*, *Goeldia*, *Psorophora*, *Deinocerites* and *Carollia*. The only suggestion of any affinity between the Australasian and Neotropical faunas seems to be in the presence in both areas of species of *Ochlerotatus* of the *taeniorhynchus* group; when the mosquitos of Patagonia are better known, it may be possible to make a more instructive comparison between the two regions. On the other hand, the genera *Bironella* and *Opifex*, two of the most interesting genera of mosquitos, are endemic in the Australasian region.

Of the 145 species dealt with, no less than 67 belong to the genus *Aedes* in the broad sense; about 25 species spread into the Oriental region, leaving the total number of known endemic species at about 120.

Tribe ANOPHELINI.

Genus *Anopheles*, Mg.

Subgenus *Anopheles*, s. str.

As is the case in other parts of the world, the Australasian species of this subgenus are not very closely related. Four are known.

Anopheles (Anopheles) stigmaticus, Skuse.

Anopheles stigmaticus, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1758 (1889).

Anopheles corethroides, Theobald, Mon. Cul. iv, p. 35 (1907).

A dark brownish species, without any ornamentation of the wings or legs, except that the hind femora are rather conspicuously pale yellowish on the basal three-fourths, leaving the apical fourth and a narrow dorsal line blackish. There are no close-lying white scales on the head. The male hypopygium of Theobald's type is in some respects rather peculiar. It has only one basal spine on the side-piece, which is set on a distinct tubercle (as in the Palaearctic *A. algeriensis*, Theo.). The claspets are conical, pointed, not lobed, with one long slender bristle at the tip, and one shorter one below it; the aedeagus is moderately long and slender, with about six pairs of very long and slender leaflets.

Taylor was probably incorrect in stating that there are scales on the mesonotum, as in Theobald's types there are only long and short hairs; in other respects these types answer completely to Taylor's and Skuse's descriptions.

NEW SOUTH WALES: Blue Mts. (*Masters*). S. QUEENSLAND: Burpengary and Alderley (*Bancroft*).

Anopheles (Anopheles) aitkeni var. *papuae* (Swellengrebel).

Stethomyia culiciformis var. *papuae*, Swellengrebel & Swellengrebel-de-Graaf, Geneesk. Tijds. Ned. Ind. lx, p. 11 (1920).

This form is known only from the larvae. Assuming the adult to resemble typical Oriental *A. aitkeni*, Theo., it differs from *A. stigmaticus* in possessing small white

scales on the vertex, and in having the hind femur only indefinitely paler towards the base, gradually shading to darker apically; also, the male hypopygium has two strong basal spines to the side-piece.

W. PAPUA: Kohas-Kaimana (*Swellengrebel*).

Anopheles (*Anopheles*) *atratis*, Skuse.

Anopheles atratis, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1755 (1889).

A black species, except for having some lighter areas on the veins in the lower half of the wing, and a distinct ochreous spot in the fringe at the tip. There are aggregations of black scales at the bases of the two fork-cells, at the base of the third vein, and at the base of the fork of the fifth vein, but none in the middle of the sixth. The scales of the palpi are outstanding at the base, but appressed on the last three segments.

NEW SOUTH WALES: Berowra (*Skuse*); Milson I. (*Cleland*). QUEENSLAND: Burpengary, etc. (*Bancroft*).

Anopheles (*Anopheles*) *bancrofti*, Giles.

Anopheles bancrofti, Giles, Handb. Gnats Ed. ii, p. 511 (early 1902).

Anopheles pseudobarbirostris, Ludlow, J.N.Y. Ent. Soc. x, p. 129 (Sept. 1902).

Anopheles barbirostris var. *bancrofti*, Taylor, Proc. Linn. Soc. N.S.W. xl, p. 176 (1915), etc.

A species with some general resemblance to *A. atratis*, but readily distinguishable by the presence of two very small pale areas on the costa, dark fringe at the extreme tip of the wing, absence of a spot of black scales at the base of the fork of the fifth vein, and presence of such a spot in the middle of the sixth vein; also, in the female, by the uniformly shaggy-scaled palpi, and the ventral scale-tuft on the last abdominal segment. From the Oriental *A. barbirostris*, v.d. Wulp, the most obvious distinction is in the presence of numerous more or less scattered pale scales on the femora and tibiae. *A. pseudobarbirostris*, Ludlow, from the Philippines, has legs similar to those of *A. bancrofti*, and also agrees in hypopygial structure; *A. barbirostris*, however, shows differences in the hypopygium which are almost certainly of specific value. The distinctions are as follows:—

A. bancrofti, Giles. Leaflets very small and short, the longest less than a third as long as the aedeagus, the rest much shorter. Basal spines of side-piece on a large prominence, each with a well marked tubercle at its base, spines about equal in length and both stout, with the tip suddenly narrowed and curved. Club very slender, almost like a blunt-ended spine, the two spines of which it is composed sometimes partly separated.

A. barbirostris, v.d.W. Leaflets much longer and darker, two or three pairs being fully half as long as the aedeagus. Basal spines on a small prominence without tubercles, both rather slender, especially the outer one, which is longer than the inner and nearly straight. Club stout, distinctly enlarged apically.

A. bancrofti is widely spread and plentiful in many parts of Queensland and the Northern Territory; it is perhaps the species recorded as *A. barbirostris* by Brug & Haga from Papua. The larvae have been described by Cooling (Proc. R. Soc. Queensland, xxxiii, p. 166, 1921).

Subgenus *Myzomyia*, Blanch.

The three or four species of this subgenus occurring within the region are all very closely related, and belong to Christophers' group *Neoanopheles*, with numerous small pale spots on the wings and numerous white spots and rings on the legs.

Anopheles (Myzomyia) amictus, Edw.

Anopheles amictus, Edwards, Bull. Ent. Res. xii, p. 71 (1921).

Differs from the next three species chiefly in having numerous scales on all the abdominal segments except the first; the palpi and proboscis are coloured as in *A. annulipes*, but the long black spots on the first longitudinal vein are mostly broken up into small dots. There is a slight but apparently good distinction in the hypopygium between this and the next species: in *A. amictus* the claspette bears two or three very short hairs apart from the apical hair, whereas in *A. annulipes* there is only one accessory hair which is fully half as long as the apical one. This is probably the northern representative of *A. annulipes*, though I believe it to be a distinct species.

QUEENSLAND: Townsville and Palm Island (Hill); Townsville (Dodd, Taylor).
NORTHERN TERRITORY: Port Darwin.

Anopheles (Myzomyia) annulipes, Walk.

Anopheles annulipes, Walker, Ins. Saund., Dipt. i, p. 433 (1856).

Anopheles musivus, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1754 (1889).

The abdomen bears scales on the last segment only. Proboscis either entirely dark or with an ill-defined pale ring beyond the middle. Female palpi with the antepenultimate segment black on the basal half, white on the apical half. The first longitudinal vein always has several long black areas below those on the costa.

Widely distributed over the whole of southern and western Australia. Northern records are doubtful; all specimens I have seen from Townsville and further north are *A. amictus* or possibly *A. mastersi*.

Anopheles (Myzomyia) mastersi, Skuse.

Anopheles mastersi, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1757 (1889).

As described by Skuse, this differs mainly if not solely from *A. annulipes* in having the proboscis entirely pale on the apical half. I have seen a few specimens which have such a proboscis, some with a scaly abdomen like *A. amictus* and some with scales at the tip only as in *A. annulipes*. These may be merely varieties of the other two species, though it is quite possible that one or more Australian species of this group await satisfactory definition.

NEW SOUTH WALES: Blue Mts. (Skuse). QUEENSLAND: Eidsvold (Bancroft).
Other records doubtful.

Anopheles (Myzomyia) punctulatus, Dön.

Anopheles punctulatus, Dönitz, Insectenbörse, xviii, p. 372 (1901).

Anopheles farauti, Laveran, C.R. Soc. Biol. liv, p. 908 (1902).

Nyssorhynchus annulipes var. *moluccensis*, Swellengrebel & Swellengrebel-de-Graaf, Bull. Ent. Res. xi, p. 89 (1920).

A much smaller species than *A. annulipes*, differing also in having a distinct ring of black scales near the end of the outer half of the antepenultimate segment of the female palpi; this ring being sometimes quite broad and connected with the black of the basal half, leaving only the tip of the segment white. As in *A. amictus* the dark areas of the first longitudinal vein are more or less broken up into dots, but as in *A. annulipes* the abdomen has scales at the tip only. In the var. *moluccensis*, which seems to be much commoner than the type form, though occurring side by side with it, the proboscis is mainly pale on the apical half, instead of all dark. The occurrence of this variation seems to support the conclusion that *A. mastersi* may be only a similar variation of *A. annulipes*.

PAPUA: Stephansort (*Dönitz*); Friedrich-Wilhelmshafen and Erima (*Bird*); Sariba and Cape Nelson (*Dr. R. Fleming Jones*); Kaimana (*Swellengrebel*).
MOLUCCAS: Halmahera, Ternate, Batjan, Sula, Buru, Ceram, Amboina, Saparua and Banda Is. (*Swellengrebel*). SOLOMON Is.: Tulagi (*G. C. H. Davies*); Tulagi, Marovovo and Rere (*Dr. A. G. Carment*). NEW HEBRIDES: Faureville, Vaté (*Laveran*); Malakula (*Ridsdale*).

Genus *Bironella*, Theo.

Although this genus is certainly very closely related to *Anopheles*, it differs from all the members of that genus in the following particulars:—(1) Upper fork-cell extremely short, as in *Megarhinus*; (2) vein *Cu*₁ distinctly wavy near the base; (3) side-piece of male hypopygium with a long curved basal arm; (4) larva with extremely long and slender anal gills. It also differs from most *Anopheles* in the absence of spiracular bristles, though these bristles are also absent in some species of the subgenus *Myzomyia*.

Bironella gracilis, Theo.

Bironella gracilis, Theobald, Ann. Mus. Nat. Hung. iii, p. 69 (1905); Edwards, Bull. Ent. Res. xiii, p. 98 (1922); Brug & Haga, Bull. Soc. Path. Exot. xv, p. 305 (1922).

A uniformly dark species, which apart from the generic characters might be confused with *A. stigmaticus*, Skuse.

PAPUA: Muina (*Bird*); Pionnierbivak (*de Rook*).

Tribe CULICINI.

In accordance with the classification adopted in my papers on the Palaearctic and Oriental mosquitos, all genera other than Anophelines are included in this tribe. The Australasian genera may be distinguished by the following key, which is adapted from the one previously given (Ind. J. Med. Res., x, 1922, p. 250) to the Culicine genera of the world.

1. Proboscis rigid, stout on the basal half, apical half slender and recurved; *r-m* cross-vein with a right-angled bend ... *Megarhinus*
Proboscis flexible, apical half not slender and recurved;
r-m cross-vein straight 2
2. Vein *An* (sixth vein) ending below or immediately before the base of the fork of *Cu* 3
Vein *An* ending well beyond the base of the fork of *Cu* 4
3. Wing-membrane without microtrichia *Uranotaenia*
Wing-membrane with numerous microtrichia *Hodgesia*
4. Upper sternopleural bristles reduced to a single one, or absent;
small spiracular bristles present *Rachionotomyia*
Several upper sternopleural bristles present 5
5. Pulvilli absent 6
Pulvilli present 14
6. Spiracular bristles present *Theobaldia*
Spiracular bristles absent 7
7. Post-spiracular bristles absent 8
Post-spiracular bristles present 10
8. Terminal antennal segments short and stout *Aedomyia*
Terminal antennal segments long and slender 9
9. Wing-scales very broad; male proboscis greatly swollen at tip *Ficalbia* (*Etorleptomyia*)
Wing-scales not very broad; male proboscis not swollen at tip *Taeniorhynchus* (*Coquillettidia*)

- | | | |
|-----|--|--------------------------------------|
| 10. | Wing-scales all very broad | <i>Taeniorhynchus (Mansonioides)</i> |
| | At least some of the wing-scales quite narrow | 11 |
| 11. | Head with hairs replacing the upright scales | <i>Opihex</i> |
| | Head with the usual upright forked scales on the nape (if only a few) | 12 |
| 12. | Cross-vein <i>m-cu</i> slightly outside <i>r-m</i> | <i>Mucidus</i> |
| | Cross-vein <i>m-cu</i> normally well inside <i>r-m</i> | 13 |
| 13. | Proboscis rather stout and somewhat recurved in repose; male | |
| | claspers with a row of spines | <i>Armigeres</i> |
| | Proboscis more slender and not recurved in repose; male claspers | |
| | without row of spines | <i>Aedes</i> |
| 14. | Several lower mesepimeral bristles | <i>Lutzia</i> |
| | At most one lower mesepimeral bristle | <i>Culex</i> |

Genus *Megarhinus*, R.-D.

The Australasian species of this genus are surprisingly few in number; all the three endemic forms belong to the same group, and might perhaps be regarded as local developments of the widely-spread Oriental species *M. splendens*, Wied. This species, with its near allies, differs from the other members of the genus in being much less restricted as to its larval habitat, and even seems to be on the way to becoming a semi-domestic species.

Megarhinus speciosus, Skuse.

Megarhina speciosa, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1722 (1889).

Readily distinguished from its allies by having the front tarsi of both sexes (not only those of the female) largely white towards the base, and the long hairs at the sides of the sixth abdominal segment mostly yellow instead of black. Larvae usually in tree-holes.

NEW SOUTH WALES: Sydney (*Masters*). QUEENSLAND: Widely distributed. NORTHERN TERR.: Darwin (*Strangman*).

Megarhinus inornatus, Walker.

Megarhinus inornatus, Walker, Proc. Linn. Soc. viii, p. 102 (1865); Edwards, Bull. Ent. Res. xiv, p. 5 (1923).

Scales of scutum rather brilliantly metallic, especially at the sides. First segment of hind tarsi of female with a white ring.

PAPUA (*Walker*); Itikimumu (*Dodd*). NEW BRITAIN: Rabaul and Mambung River (*Hill*). BURU (*Toxopeus*).

Megarhinus subulifer, Dol.

Megarhinus subulifer, Doleschall, Nat. Tijds. Ned. Ind. xiv, p. 382 (1857).

Megarhinus immisericors, Walker, Proc. Linn. Soc. iv, p. 91 (1860).

Differs from *M. inornatus* in the duller almost brownish scales of the scutum (at least over the middle) and the absence of a white ring on the first hind tarsal segment of the female. It is probably only a variety of the Oriental *M. splendens* Wied., which differs only in the markings of the underside of the abdomen.

AMBOINA (*Doleschall*). CELEBES (*Walker*).

Genus *Uranotaenia*, Theo.

Of this genus eight species are at present known from the Australasian region, six of which belong to the first section, with a line of broad blue or white scales in front of the wing-base, the other two (*nigerrima*, Taylor, and *papua*, Brug) falling into the second section, which does not possess these scales.

Uranotaenia nivipes* (Theo.).Anisocheleomyia nivipes*, Theobald, Entom. xxxviii, p. 52 (1905).*Uranotaenia albofasciata*, Taylor, Proc. R. Soc. Vict. xxxii, p. 164 (1920).

Very distinct from the other Australasian species by the largely white-scaled wings, the scales at the tip of the wing being all pale, and by the whitish yellow front of the scutum and upper half of the pleura, contrasting strongly with the rest of the thorax, which is dark brown. I have previously regarded this as identical with the Oriental *U. nivea*, but there are some small differences: in the Australian form the upper half of the pleura is more conspicuously whitish, and the scales in the upper corner of the sternopleura are white instead of black. A paratype of Taylor's species was compared with Theobald's type and found identical.

QUEENSLAND: Townsville (Taylor); Deception Bay (Bancroft).

Uranotaenia albescens*, Taylor.Uranotaenia albescens*, Taylor, Trans. Ent. Soc. 1913, p. 705 (1914).

This is very similar to the Oriental *U. argyrotarsis*, Leic., but may be regarded as distinct, since it has the basal half of the third hind tarsal segment dark, whereas in the Oriental form the whole of the last three hind tarsal segments are white. A female paratype shows that, as in *U. argyrotarsis*, there is a narrow and continuous blue stripe across the pleura from the neck to the base of the abdomen, the stem of the fifth vein (*Cu*) as well as the extreme base of the first vein (*R*) is clothed with white scales, and the first three and the fifth abdominal tergites are largely white scaled.

QUEENSLAND: Townsville, Cairns (Taylor).

Uranotaenia tibialis*, Taylor.Uranotaenia tibialis*, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 839 (1919).

I have examined a female of this species determined by Taylor and find that it is in nearly all respects similar to *U. albescens*, but the abdomen is entirely dark above. Taylor describes the male as having an apical scale-tuft on the front tibia, which certainly does not occur in the allied *U. argyrotarsis*, Leic.

QUEENSLAND: Cairns (Taylor).

Uranotaenia pygmaea*, Theo.Uranotaenia pygmaea*, Theobald, Mon. Cul. ii, p. 254 (1901).

Resembles the last two in its thorax and wings, but the abdomen has a rather narrow whitish band at the apices of each of segments 2-6, and the hind tarsi are dark to the tip.

QUEENSLAND: Burpengary, Deception Bay and Enoggera (Bancroft).

Uranotaenia atra*, Theo.Uranotaenia atra*, Theobald, Ann. Mus. Nat. Hung. iii, p. 114 (1905).*Uranotaenia cancer*, Leicester, Cul. of Malaya, p. 215 (1908).*Uranotaenia propria*, Taylor, Trans. Ent. Soc. 1913, p. 704 (1914).*Uranotaenia cairnsensis*, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 839 (1919).

Differs from the last three species in having no white scales on the wings, and in having only a central patch, not a continuous narrow stripe of blue scales on the pleura. Apart from this the species may easily be known by the remarkable modification of the front tarsi of the male. The pubescence of the antennal flagellum of the

female is evenly spread along the segments. I have examined specimens of Taylor's *U. propria* and *U. cairnsensis* and find them to agree with the Oriental form.

The species is a breeder in crab-holes, though not confined to such places.

PAPUA: Muina (*Bird*). QUEENSLAND: Townsville (*Priestley*); Cairns (*Taylor*).

***Uranotaenia antennalis*, Taylor.**

Uranotaenia antennalis, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 840 (1919).

Agrees with the last species in having no white scales on the wings and no continuous line across the pleura, but all the blue scales of the thorax are replaced by silvery white, and the fine pubescence of the antennal flagellum is confined to the tips of the segments. The proboscis is longer than the abdomen, the latter being all dark above. The tips of the tarsi were said to be pale, but this was not the case in the paratype examined.

QUEENSLAND: Cairns (*Taylor*).

***Uranotaenia papua*, Brug. Bull. Ent. Res. xiv, p. 437 (1924).**

Uranotaenia papua, Brug.

A small obscure species without any special ornamentation; the thorax uniformly brownish ochreous; the proboscis very short. It is nearly allied to the Oriental *U. brevisrostris*, Edw., and *U. moultoni*, Edw.

N. PAPUA: Pionnier-Bivak (*de Roo*).

***Uranotaenia nigerrima*, Taylor.**

Uranotaenia nigerrima, Taylor, Trans. Ent. Soc. 1914, p. 203 (1914).

Although without special ornamentation of scales, this species is quite sharply marked off from the other Australasian forms by the two pairs of large velvet-black spots on the thoracic integument, which are quite conspicuous even though the rest of the thorax is very dark brown; these spots are situated on the proepimera and on the scutum just in front of the wing-bases. Taylor's description does not mention them, but they are present in his type, though hidden by shrivelling due to immaturity.

U. nigerrima is very closely allied to the Oriental *U. bimaculata*, Leic., differing chiefly in its darker tint and in small details of the structure of the hypopygium.

PAPUA: Milne Bay (*Breinl*); Lakekamu (*Giblin*). NEW BRITAIN: Rabaul (*Hill*).

Genus *Hodgesia*, Theo.

Three Australasian species of this genus have been described, all from captured females only. They are all very similar, differing in the colour of the thoracic integument and in the markings of the abdomen.

***Hodgesia quasisanguinae*, Leic.**

Hodgesia quasisanguinae, Leicester, Cul. of Malaya, p. 230 (1908).

Hodgesia triangulatus, Taylor, Trans. Ent. Soc. 1914, p. 204 (1914).

The thoracic integument in the typical form is entirely shining black, though in the specimens from Darwin (which may indeed represent a distinct species) the pleura and the front of the scutum are more or less ochreous. The abdomen in both forms has distinct silvery lateral spots on tergites 2, 3, 5 and 6 (none on 4), those on 3 and

5 being larger than the others though rather variable in size. After comparison I can find no difference between specimens from the Malay Peninsula and North Queensland, and have therefore adopted Leicester's name.

PAPUA: Lakekamu (*Giblin*). QUEENSLAND: Cairns (*Taylor*). NORTHERN TERRITORY: Darwin (*Hill*).

***Hodgesia cairnsensis*, Taylor.**

Hodgesia cairnsensis, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 842 (1919).

Differs from the last species in the colour of the thoracic integument, which is mostly ochreous, but with a large oval black spot in front of each wing-root, and a blackish brown area in the middle between these two spots. This median dark area is variable in extent, widening out anteriorly and sometimes almost reaching the front margin of the scutum; in the lightest specimens it is represented by two divergent dark lines. The abdominal markings are practically the same in the two species, though in *H. cairnsensis* the silvery lateral areas on the fifth tergite seem to extend on the average nearer to the mid-dorsal line.

QUEENSLAND: Cairns (*Taylor*). PAPUA: Mekeo (*Hill*). NEW BRITAIN: Rabaul (*Hill*).

The specimens from Darwin, N.T., mentioned under *H. quasisanguinae*, may belong here, but they seem to be intermediate in coloration, and may perhaps indicate that the two forms *quasisanguinae* and *cairnsensis* are only varieties of one species.

***Hodgesia spoliata*, Edw.**

Hodgesia spoliata, Edwards, Bull. Ent. Res. xiv, p. 8 (1923).

Differs from the last two in having no silvery markings on the abdomen. The thoracic integument is almost entirely black.

PAPUA: Mekeo District (*Hill*).

Genus ***Rachionotomyia*, Theo.**

Since the distinction between *Rachionotomyia* and *Rachisoura* rests almost entirely on the greater length of the proboscis in the former, and since, moreover, several species are more or less intermediate in this respect, I propose to unite the two genera under the earlier name. The group evidently corresponds to the American *Wyeomyia*, from which it differs in the absence of postnotal bristles. In *Wyeomyia* also the proboscis is variable in length in the different species, the subgenus *Phoniomyia* being analogous to *Rachionotomyia* (s. str.) in its long slender proboscis.

Little is known as to the life-history of the Australian species. *R. caledonica* has been reared from pitcher-plants, and Bancroft states that *R. atripes* is sometimes found in water-butts, though this may not be the normal habitat of the species. Some of the Oriental species live in bamboos, and the same may be true of the allied Australasian forms with spotted femora.

The following key will distinguish the known Australasian species:—

- | | | | | |
|---|-----|-----|-----|-----------------------------|
| 1. Femora with preapical white or silvery spots in front | ... | ... | ... | 2 |
| Femora not spotted in front | ... | ... | ... | 6 |
| 2. Tarsi tipped with white | ... | ... | ... | <i>argyropus</i> (Walk.) |
| Tarsi not tipped with white | ... | ... | ... | 3 |
| 3. Femora with only one distinct spot; pronotal scales narrow | ... | ... | ... | <i>magnesiiana</i> , sp. n. |
| Femora each with two distinct spots; pronotal scales broad | ... | ... | ... | 4 |
| 4. Integument of scutum mainly blackish | ... | ... | ... | <i>bimaculipes</i> (Theo.) |
| Integument of scutum orange | ... | ... | ... | 5 |

- | | | | | | | |
|-----|--|-----|-----|-----|--------------------------------|----|
| 5. | Abdomen without purple gloss | ... | ... | ... | <i>quasiornata</i> (Taylor) | |
| | Abdomen with strong purple gloss | ... | ... | ... | <i>purpurata</i> , Edw. | |
| 6. | Head blue-scaled | ... | ... | ... | <i>ornata</i> (Taylor) | |
| | Head black-scaled, a narrow white margin round the eyes in front | ... | ... | ... | | 7 |
| 7. | Tip of hind tibia and last two segments of hind tarsi white | ... | ... | ... | <i>lasmaniensis</i> (Strick.) | |
| | These parts dark | ... | ... | ... | ... | 8 |
| 8. | A light stripe across pleural integument clothed with white scales, | | | | | |
| | the darker parts nearly bare | ... | ... | ... | <i>caledonica</i> , Edw. | |
| | Pleural integument uniformly dark, and densely clothed with white scales | ... | ... | ... | | 9 |
| 9. | Wing-scales narrow | ... | ... | ... | ... | 10 |
| | Wing-scales all broad | ... | ... | ... | ... | 12 |
| 10. | Proboscis slender, as long as the whole body | ... | ... | ... | <i>argenteiventris</i> (Theo.) | |
| | Proboscis stouter, not longer than the abdomen | ... | ... | ... | ... | 11 |
| 11. | No white scales in front of scutellum | ... | ... | ... | <i>atripes</i> (Skuse) | |
| | White scales surrounding bare space in front of scutellum | ... | ... | ... | <i>solomonis</i> , sp. n. | |
| 12. | Abdominal tergites with apical lateral white spots... | ... | ... | ... | <i>filipes</i> (Walk.) | |
| | These spots absent | ... | ... | ... | <i>atra</i> (Taylor) | |

***Rachionotomyia argyropus* (Walker).**

Culex argyropus, Walker, List Dipt. Brit. Mus. i, p. 2 (1848).

Uranotaenia argyropus, Theobald, Mon. Cul. ii, p. 264 (1901).

This species stands quite apart from all the other members of the genus, not only because of its conspicuously distinctive ornamentation, but also owing to its possession of from 2-4 strong proepimeral * bristles, the other species having one only, and even this often very small or even absent. The remaining structural characters being essentially the same as in *Rachionotomyia*, there is perhaps no necessity for erecting a new genus for this species. It cannot be placed in *Theobaldia*, because the upper sternopleural bristles are reduced to one only.

Apart from the white-tipped tarsi (on the front tarsi the fourth but not the fifth segment is white) the insect may be known by the white ring in the middle of the palpi, the broad stripe of flat silvery-white scales along the margin of the scutum, and by the rather narrow silvery-white stripe across the pleura, this last feature recalling *R. caledonica*, Edw. The proboscis is stouter and less elongate than in the other species with spotted femora.

The adults are found resting on tree-trunks. The larval habits have not been recorded, but this is perhaps the species referred to by Miller as breeding in epiphytic *Astelias* on the North Auckland peninsula.

NEW ZEALAND: Wellington district (*Hudson*); Ohakune (*Harris*).

***Rachionotomyia bimaculipes* (Theo.).**

Phoniomyia bimaculipes, Theobald, Ann. Mus. Nat. Hung. iii, p. 114 (1905).

The group to which this species belongs is distinguished by the brilliant silvery markings on the abdomen; a large silvery patch on the pleura; absence of upper sternopleural bristle; azure blue head (when seen from in front); short palpi, hardly longer than the clypeus in either sex, and silvery spots on the front of the femora. The diagnostic characters of *R. bimaculipes* are the small broad scales on the pronotal lobes, the largely shining blackish integument of the mesonotum, and the dull black colour of the dark scales of the abdomen.

PAPUA: Moroka and Friederich-Wilhelmshafen (*Bird*).

* It has recently been shown by Mr. S. B. Freeborn that the sclerites which have hitherto been called proepimera in mosquitos are really the posterior portions of the pronotal lobes. But for present convenience the term "proepimeral bristles" has been retained in this paper.

***Rachionotomyia quasiornata* (Taylor).**

Stegomyia quasiornata, Taylor, Proc. Linn. Soc. N.S.W. xl, p. 177 (1915).

Closely allied to *R. bimaculipes*, differing only in the uniformly orange integument of the scutum. The proepimera have narrow scales, and the scutal scales are black.

The specimen mentioned by me (Bull. Ent. Res. xii, p. 80, 1921) as this species was really *R. magnesiana*. Subsequent examination of Taylor's type female showed that two species had been confused.

QUEENSLAND: Innisfail (Taylor). NEW BRITAIN: Toma (Hill).

***Rachionotomyia purpurata*, Edw.**

Rachionotomyia purpurata, Edwards, Bull. Ent. Res. xii, p. 79 (1921).

Very similar to the last two, but differs from both in the strong purple gloss on the dorsum of the abdomen, the tergites, however, having basal lateral dull black triangles. The scutum is entirely dull orange, and clothed mostly with greenish scales; the proepimera have broad scales like those of the pronotal lobes.

Fiji: Suva (Bahr), reared from larvae found in an old kerosene tin.

***Rachionotomyia magnesiana*, sp. n.**

Nearly related to *R. purpurata*, Edw., and with a similar coloration of the abdomen, but differs as follows:—Scales of pronotal lobes narrow and hairlike. Thoracic integument shining, the scutal scales black. Femora rather shorter and stouter, and with only one distinct silvery spot close to the tip; the middle femora have a silvery line in front extending along the basal two-thirds, this being faintly indicated also on the front femora. Wing-scales distinctly smaller and scantier.

QUEENSLAND: Magnetic Island, 24.xi.1920 (G. F. Hill); 1 ♀ presented by the collector to the British Museum.

***Rachionotomyia ornata* (Taylor).**

Stegomyia ornata, Taylor, Trans. Ent. Soc. 1914, p. 189 (1914), and Proc. Linn. Soc. N.S.W. xli, p. 565 (1916).

I have not seen this species, but from Taylor's description it evidently belongs here. In its blue head, together with the unspotted femora, it seems quite distinct from the other Australian species, but most closely resembles the Oriental *R. affinis*, Edw., which is a pitcher-plant breeder.

PAPUA: Milne Bay (Breint).

***Rachionotomyia argenteiventris* (Theo.).**

Polylepidomyia argenteiventris, Theobald, Ann. Mus. Nat. Hung. iii, p. 118 (1905).

This belongs to the same group as the last, but is quite distinct by the black head with a narrow bluish-white border round the eyes, and the white instead of brown scales on the pronotal lobes and proepimera. It is very similar to the Oriental *R. aranoides* (Theo.), the type of the genus, but appears to be distinct by having only one minute claw on the hind tarsus, a distinct upper sternopleural bristle, etc.

PAPUA: Paumotu River (Biró).

***Rachionotomyia caledonica*, Edw.**

Rachionotomyia caledonica, Edwards, Bull. Ent. Res. xiii, p. 100 (1922).

This and the next species are somewhat intermediate between *Rachionotomyia* (s. str.) and *Rachisoura*, because, although the proboscis is long and slender as in the

former group, the male palpi are long as in the latter. *R. caledonica* is well distinguished from the other species of the genus by the pleural markings; it further differs from *R. tasmaniensis*, its nearest ally, in the entirely dark tibiae and tarsi. There is a distinct upper mesepimeral bristle, and dorsocentral bristles on the scutum.

NEW CALEDONIA: Houailou (*Montague*); bred from pitcher plants.

***Rachionotomyia tasmaniensis* (Strick.).**

Stegomyia tasmaniensis, Strickland, Entom. xlv, p. 249 (1911); Taylor, Proc. Linn. Soc. N.S.W. xli, p. 564 (1916).

Rachionotomyia cephasi, Edwards, Bull. Ent. Res. xiv, p. 8 (1923).

Very distinct from the other species of the genus by the white apical spots of the tibiae (especially those of the hind legs), and the white tips to the hind tarsi. The chaetotaxy is practically the same as in *R. caledonica*, and the male palpi are presumably long, though not actually mentioned by Taylor.

In describing *R. cephasi*, I unfortunately overlooked the fact that Strickland's *S. tasmaniensis* belongs to this genus. The species are obviously identical.

TASMANIA: Launceston, Mt. Arthur, Devonport, St. Patrick's River, Springfield, Bridport (*Littler*); New River (*Twelvevrees*); Mole Creek (*C. L. Edwards*).

***Rachionotomyia filipes* (Walk.).**

Culex filipes, Walker, Proc. Linn. Soc. v, p. 229 (1861).

Rachisoura sylvestris, Theobald, Mon. Cul. v, p. 208 (1910).

Stegomyia hilli, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 456 (1914).

Mimeteomyia hilli, Taylor, Proc. Linn. Soc. N.S.W. xli, p. 566 (1916).

Distinct from all the other species of the genus except *R. atra* by the broad wing-scales. The proboscis is shorter and stouter than in any of the above-mentioned species, being scarcely longer than the front femora. The palpi of the male are about two-thirds, of the female one-fifth as long as the proboscis. The abdominal tergites have distinct apical lateral white spots.

PAPUA: Dorey (*Wallace*). QUEENSLAND: Kuranda (*Bancroft*). N. TERRITORY: Stapleton and Melville Island (*Hill*).

***Rachionotomyia atra* (Taylor).**

Stegomyia atra, Taylor, Trans. Ent. Soc. 1914, p. 190 (1914).

Very close to *R. filipes*, but the abdomen has hardly a trace of apical lateral pale spots on the tergites. A paratype female examined shows the following characters: One pre-epimeral bristle, three strong dark spiraculars; proepimeral scales dense, white below and brown above. Palpi 2.5 times as long as the clypeus. Wing-scales broad.

PAPUA: Lakekamu, Mungana (*Giblin*).

***Rachionotomyia atripes* (Skuse).**

Culex atripes, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1750 (1889).

Stegomyia punctolateralis, Theobald, Entom. xxxvi, p. 156 (1903).

Mimeteomyia apicotriangulata, Theobald, Mon. Cul. v, p. 211 (1910).

As Theobald says, this looks very much like a small *R. filipes*, but differs in having the wing-scales quite narrow. Further, the hind tibiae are largely whitish beneath, and the male palpi are as long as the proboscis.

According to Bancroft, "the larvae are found occasionally in water-butts and tanks," a very unusual habitat for a species of this genus. He also remarks that the hind legs are "cocked up and bent forwards," an attitude which has been recorded for other Sabethine genera.

The type of *M. apicotriangulata* appears to have the scutal scales a little broader than usual, but I do not think it can be a distinct species.

NEW SOUTH WALES: Homebush (*Masters*); Sutherland and Knapsack Gully (*Skuse*); Milson I. (*Cleland, Ferguson*); Blackheath (*Thompson*); Ingleburn (*Taylor*). QUEENSLAND: Brisbane, Eidsvold (*Bancroft*); Burketown, Townsville (*Taylor*); Malanda and Palm I. (*Hill*). VICTORIA: Mildura (*Taylor*).

***Rachionotomyia solomonis*, sp. n.**

Nearly related to *R. atripes* (*Skuse*), differing as follows:—General coloration much darker; scutal scales black, but with a conspicuous margin of pure white scales round the bare space in front of the scutellum, also more numerous white scales round the front of the mesonotum; dorsum of abdomen with a strong bluish gloss; front and middle femora much less extensively white beneath; upper fork-cell relatively somewhat longer.

SOLOMON IS.: Tulagi, Guadalcanar I., vii, 1923 (*Dr. A. G. Carment*), 1 ♀ caught in house; presented to the British Museum by the collector.

Genus *Theobaldia*, N.-L.

No species of this genus has hitherto been reported from the region, but I find that two species described (under other generic names) from Australia should be referred here. Though resembling *Culex* in general appearance, they agree with the Palaearctic species of *Theobaldia* in all important respects, especially in the pleural chaetotaxy, absence of pulvilli, and structure of male and female genitalia. The cross-veins are not noticeably approximated, but this has been proved to be a character of no importance generically. The male palpi are much more slender and less hairy than in the European species. There are two or three small but distinct spiracular bristles, which are pale in colour as usual in this genus, and may require rather close observation before their presence is detected. The Australian species are perhaps nearest to the subgenus *Culicella*, but until the larvae are known it would be premature either to assign them to that subgenus or to erect a new one for their reception.

***Theobaldia frenchi* (Thco.).**

Culex frenchii, Theobald, Mon. Cul. ii, p. 66 (1901).

A rather small species about the size of *Culex fatigans*, with reddish thorax, dark unbanded abdomen, and dark tarsi. The proepimera have rather numerous narrow curved scales. The male has recently been obtained for the first time by Mr. G. F. Hill; its hypopygium has the anal and genital parts with claspers as in typical *Theobaldia*, but the side-pieces are rather peculiar in having a long basal process, hairy at its tip, which rather suggests the definite claspette structure of *Taeniorhynchus*, though without a terminal spine.

VICTORIA: locality unstated (*French*); Beaconsfield (*Hill*).

***Theobaldia littleri* (Taylor).**

Chrysiconops littleri, Taylor, Trans. Ent. Soc. 1913, p. 702 (1914).

The type is closely similar to *T. frenchi*, except that the scales on the proepimera are fewer and more hair-like. It is very likely nothing more than a variety of *T. frenchi*.

TASMANIA: Mt. Arthur (*Littler*).

Genus **Aëdomyia**, Theo.

This genus is probably more or less nearly related to *Taeniorhynchus*, in spite of the very different specialisation of the larvae. Apart from the structural character of the antennae, the species may be recognised by its very broad and dense wing-scales and the scale-tufts at the tip of the femora.

Aëdomyia venustipes (Skuse).

Aedes venustipes, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1761 (1889).

Aëdomyia catasticta, Knab, Ent. News, p. 387 (1909).

Having now compared specimens from the two regions, I am convinced that the Oriental and Australian forms are identical.

NEW SOUTH WALES: Elizabeth Bay, Sydney (*Skuse*). QUEENSLAND: Eidsvold (*Bancroft*); Townsville (*Taylor*). NORTHERN TERR.: Darwin (*Taylor*). Also throughout the Oriental Region; larva in swamps, associated with "water-lettuce" (*Pistia*).

Genus **Ficalbia**, Theo.

Only one Australian species of this genus is known, which according to Taylor's description belongs to the same group as the Oriental *F. luzonensis* (Ludl.) and the African *F. mediolineata* (Theo.). All three species have been placed in Theobald's genus *Etorleptomyia*, and as Drs. Ingram and Macfie have recently shown, the African species at least shows some rather striking differences in the larva and pupa from the more typical *F. malfeyti* (Newst.). Further material of the early stages of other species is desirable before an opinion can be expressed as to whether *Etorleptomyia* should be regarded as a distinct genus or subgenus. Apart from the difference in the shape of the wing-scales, to which I attach little importance, the adult structure is very much the same in all the species of the genus.

Ficalbia elegans (Taylor).

Dixomyia elegans, Taylor, Trans. Ent. Soc. 1913, p. 703 (1914).

According to Taylor's description this differs from *F. luzonensis* (Ludl.), the Oriental representative of the group, in the less extensively yellow legs and the black-scaled abdomen.

QUEENSLAND: Townsville (*Priestley*).

Genus **Taeniorhynchus**, Arr.

Two of the three subgenera of *Taeniorhynchus* are well represented in the Australasian region: *Mansonioides*, in which post-spiracular bristles are present, all the wing-scales very broad, male palpi slender and upturned with minute terminal segment, and seventh segment of female abdomen much reduced; and *Coquillettidia*, in which post-spiracular bristles are absent, many of the wing-scales rather narrow, male palpi with the last segment quite large and not upturned, and seventh segment of female abdomen normal. In the subgenus *Mansonioides* only one species is endemic to the region, the remaining three all having a wide external distribution. On the other hand, in the subgenus *Coquillettidia* four out of the six species are endemic, one at least of the remaining two showing varietal modification.

Taeniorhynchus (Mansonioides) papuensis, Taylor.

Taeniorhynchus papuensis, Taylor, Trans. Ent. Soc. 1914, p. 200 (1914).

Although apparently a typical member of the subgenus, this differs from all the other known species in having the wing-scales uniformly dark, instead of mixed dark

and light, and in the almost completely dark tarsi and the very indistinct pale markings on the femora and tibiae. It is one of the smallest species of the subgenus. The male is at present unknown.

PAPUA: Lakekamu (*Giblin*); Mekeo (*Hill*).

Taeniorhynchus (Mansonioides) annulipes (Walk.).

Culex annulipes, Walker, Proc. Linn. Soc. i, p. 5 (1857).

? *Mansonia septempunctata*, Theobald, Ann. Mus. Nat. Hung. iii, p. 187 (1905).

Distinguished by the rather conspicuous whitish spots on the scutum; it resembles the Oriental *M. annuliferus*, but is larger and has the thoracic integument much darker. Recorded in error by Hill as *M. septemguttata*.

QUEENSLAND: Cairns (*Hill*). PAPUA: Friedrich Wilhelmshafen (*Bird*); Lakekamu (*Giblin*); Mekeo (*Breinl*).

Taeniorhynchus (Mansonioides) africanus (Theo.).

Panoplitis africana, Theobald, Mon. Cul. ii, p. 187 (1901).

The thorax is rather dark brownish, without special ornamentation, and the markings on the femora and tibiae are pure white. I believe the Queensland specimens are conspecific with the African, but no males are yet available for comparison.

QUEENSLAND: Halifax and Innisfail (*Taylor*).

Taeniorhynchus (Mansonioides) uniformis (Theo.).

Panoplitis uniformis, Theobald, Mon. Cul. ii, p. 180 (1901).

Panoplitis australiensis, Giles, Handb. Gnats Ed. ii, p. 355 (1902).

Distinguished from *T. africanus*, Theo., by the lighter tint of the thoracic integument, the two longitudinal bands of pale greenish scales on the scutum, and the less sharply defined and more ochreous-tinged markings on the femora and tibiae.

PAPUA: Lakekamu (*Giblin*); Milne Bay (*Breinl*). DUTCH E. INDIES: Celebes, Ceram (*Brug*); Buru (*Toxopeus*). QUEENSLAND: Moreton Bay (*Bancroft*); Cairns, Townsville (*Hill*). NORTHERN TERR.: various localities (*Taylor*). Also throughout the Oriental and Ethiopian regions.

Taeniorhynchus (Coquillettia) giblini (Taylor).

Pseudotaeniorhynchus conopas var. *giblini*, Taylor, Trans. Ent. Soc. 1914, p. 198 (1914).

A very distinct species on account of its yellow colour, black-ringed legs, and black markings on the integument of the thorax. I can see no constant difference between Australian and Oriental females, and believe them to be identical, but males have not yet been compared.

PAPUA: Lakekamu (*Giblin*). Also widely spread in the Oriental region.

Taeniorhynchus (Coquillettia) brevicellulus, Theo.

Taeniorhynchus brevicellulus, Theobald, Mon. Cul. ii, p. 212 (1901).

This also is a very easily recognised species, with a yellow or brownish yellow thorax, and almost entirely dark purple legs. The male abdomen is rather remarkable, the seventh sternite bearing a large tuft of long bristles, the eighth sternite large and pointed, the hypopygium large, turned upwards and very bristly; the side-pieces have a small patch of fine hair on the inner side at the tip, but no definite lobe. The only Australasian specimens I have seen are a few from Fiji; these differ from the

average Oriental form in having the abdomen more extensively purple scaled, and in the apparent absence of a small filament on the male clasper near the base of the inner margin.

PAPUA: Lakekamu (*Giblin*). NEW CALEDONIA (*Theobald*). FIJI: Nausori and Labasa (*Veitch*). BURU (*Toxopeus*).

Taeniorhynchus (Coquillettia) xanthogaster, nom. n.

Taeniorhynchus acer, Theobald (*nec* Walker), Mon. Cul. ii, p. 211 (1901).

This is the Australian representative of *T. brevicellulus*, from which it differs externally chiefly in the almost entirely yellow abdomen, which has hardly any purple scales. The abdomen is rather variable in colour in the Oriental form, and at one time I thought that these yellow specimens merely represented an extreme variation, but having now studied the male hypopygium I find that there is a conspicuous difference: in *T. xanthogaster* the side-piece has a broad flat apical lobe projecting inwards, square-ended and bearing a dense apical fringe of dark hair; the clasper also is of rather a different shape from that of *T. brevicellulus*.

An examination of Walker's type of *Culex acer* shows that it is certainly not this species, but a worn and faded *Culex*, probably *C. fatigans*. The present species probably does not occur in New Zealand.

QUEENSLAND: Burpengary (*Bancroft*); Townsville (*Hill*). NORTHERN TERRITORY: various localities (*Hill*).

Taeniorhynchus (Coquillettia) linealis (Skuse).

Culex linealis, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1747 (1889).

Although I have not seen a male of this species I have no doubt it is correctly placed here. It differs from the above three species and agrees with the two following in the dark brown thoracic integument. From all the other species it differs in the rather definite lines of golden scales on the scutum, and in having indistinct whitish rings at the bases of the first two or three hind tarsal segments.

NEW SOUTH WALES: Blue Mts., Hexham and Wheeny Creek (*Skuse*). QUEENSLAND: Enoggera (*Bancroft*). VICTORIA: Beaconsfield (*Hill*).

Taeniorhynchus (Coquillettia) iracundus (Walk.).

Culex iracundus, Walker, List Dipt. Brit. Mus. i, p. 6 (1848).

Venter with whitish scales, but with very distinct apical dark bands on the sternites. Hind femora dark all round at the tip. Wing-scales all broadish, ligulate. Palpi of the male not much longer than the proboscis; last two segments rather densely hairy, together only about half as long as the long segment; apex of long segment and base of penultimate segment somewhat swollen. Palpi of female barely a fifth as long as the proboscis. Terminal segment of male antennae barely as long as the penultimate, the plumes moderately dense. Male clasper with a large flat expansion on the outer side about the middle; inner margin gently curved, entire.

NEW ZEALAND: North Auckland district and Great Barrier Is. (*Miller*); Ohakune (*Harris*).

Taeniorhynchus (Coquillettia) tenuipalpis, sp. n.

Resembles *T. iracundus* but larger, and also shows the following differences:—Thoracic integument more shining. Venter mostly pale-scaled, the sternites without distinct apical dark bands. The hind femora are pale to the tip on the outer side. Many of the outstanding wing-scales are quite narrow, almost linear. Palpi of the male considerably longer than the proboscis, and of uniform thickness throughout;

the last two segments together about equal in length to the long segment and almost devoid of hair. Palpi of female about one-fourth as long as the proboscis. Terminal segment of male antennae nearly half as long again as the penultimate, plumes more scanty than in *T. iracundus*. Male clasper without noticeable expansion on the outer side, but with a small obliquely-placed flat expansion on the inner side a little beyond the middle.

NEW ZEALAND: Ohakune, i, 1924 (*T. R. Harris*); type ♂ and paratype 3 ♂ 3 ♀ presented by the collector. Also two other ♀ taken at the same place, i. 1920 and i. 1923.

Genus *Opifex*, Hutton.

This remarkable genus includes only a single species, which is known only from the coasts of New Zealand, the larvae living in brackish pools on the shore. It shows some decidedly primitive features, notably in the presence of hairs instead of upright scales on the head, but it has lost its pulvilli, and in this respect as well as in its chaetotaxy and larval characters it shows affinity with the *Aedes* rather than with the *Culex* group of genera. I see no justification for treating it as forming a separate tribe, as has been proposed by Miller.

Opifex fuscus, Hutton.

Opifex fuscus, Hutton, Trans. N.Z. Inst. xxxiv, p. 188 (1902); Edwards, Bull. Ent. Res. xii, p. 73 (1921); Miller, Bull. Ent. Res. xiii, p. 115 (1922).

Especially remarkable for the secondary sexual characters of the male: the absence of plumes and presence of spines on the antennae, and the very large and equal front claws. A stoutly-built, dark species.

NEW ZEALAND: Wellington (*Hudson*); rocky coasts of North Island (*Miller*).

Genus *Mucidus*, Theo.

This genus, though very easily recognised by the striking ornamentation and the relative position of the cross-veins, is really quite closely related to the subgenus *Ochlerotatus* of *Aedes*. There are two Australasian species.

Mucidus alternans (Westw.).

Culex alternans, Westwood, Ann. Soc. Ent. France, iv, p. 681 (1835).

Culex commovens, Walker, Ins. Saund., Dipt. i, p. 432 (1856).

Culex hispidosus, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1726 (1889).

A large species which could not be confused with any other in the Australian fauna, owing to the shaggily-scaled legs with white rings on the tibiae as well as the tarsi. Larvae in shallow swamps.

VICTORIA: Kyabram (*Taylor*). NEW SOUTH WALES: Hexham and Richmond (*Skuse*); Mt. Kemble (*Masters*); Yarrawin (*Froggatt*). QUEENSLAND: Burpengary and Kuranda (*Bancroft*); Townsville (*Priestly*); Normanton, Rockhampton, Mackay (*Taylor*). NORTHERN TERR.: Darwin (*Strangman*). PAPUA: Port Moresby (*Armitage*); Breakfast Creek (*Tryon*). NEW CALEDONIA: Noumea (*J. J. Walker*, 1 ♀ in British Museum).

Mucidus kermorganti (Laveran).

Culex kermorganti, Laveran, C.R. Soc. Biol. liii, p. 568 (1901).

Mucidus kermorganti, Edwards, Bull. Ent. Res. xiii, p. 99 (1922).

This is quite possibly only a form of the preceding, as it only differs in having the scales of the legs appressed, the coloration being identical. Both forms occur in New Caledonia, though *M. kermorganti* has not yet been found outside the island.

NEW CALEDONIA: Noumea (*Laveran*); Calama (*Delacour*).

Genus **Armigeres**, Theo.

Although this genus has not been found on the mainland of Australia, three species occur in New Guinea and adjacent islands. All are closely related to if not identical with Oriental forms, and are distinguishable from one another chiefly by hypopygial characters.

Armigeres breinli (Taylor).

Neosquamomyia breinli, Taylor, Trans. Ent. Soc. 1914, p. 186 (1914).

Armigeres breinli, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 828 (1919).

Distinguished in both sexes from the other two species by the presence of two patches of white scales on the clypeus. The hypopygium of the specimen described and subsequently figured by Taylor is identical with that of the Oriental *A. malayi* (Theo.) of which *A. breinli* is probably nothing more than a variety with dark bands on the venter.

PAPUA: Milne Bay (*Breinli*); Mungana (*Giblin*).

Armigeres obturbans (Walker) var. ?

Among several specimens received from Mr. G. F. Hill that had been determined as *A. breinli* by Taylor were two or three females and one male of a quite distinct species without clypeal scales. Mr. Hill had mounted the hypopygium of this male, which was labelled as type of *A. breinli*, though obviously not the one which had served for the description. In structure it resembles that of *A. obturbans*, though the basal lobe of the side-piece is larger, with more distinct spiny bristles, which are curved at their tips, and the teeth on the clasper are rather more numerous and extend nearly to the base.

PAPUA: Milne Bay? (*Breinli*).

Armigeres lacuum, Edw.

Armigeres lacuum, Edwards, Bull. Ent. Res. xiii, p. 97 (1922).

Differs from the above, in the male sex, by the dense tuft of hair on the basal lobe of the side-piece. No definite distinction between the females of the two species can be pointed out. *A. lacuum* seems to be the Australasian representative of the Oriental *A. confusus*, Edw.

ILE DES LACS (Biró). NEW BRITAIN: Toma and Beining (*Hill*).

Genus **Aedes**, Mg.

The subgenera of *Aedes* (including, for comparison, the genus *Armigeres*) occurring within the region may be separated by the following more or less artificial keys, which will not necessarily hold good for species of other regions.

Males.

- | | | | | | | | | |
|--|-----|-----|-----|-----|-----|-----|-----|------------------------|
| 1. Palpi very short | ... | ... | ... | ... | ... | ... | ... | 2 |
| Palpi at least half as long as the proboscis | ... | ... | ... | ... | ... | ... | ... | 3 |
| 2. Scutellum with narrow scales only | ... | ... | ... | ... | ... | ... | ... | <i>Aedes</i> |
| Scutellum with broad flat scales only | ... | ... | ... | ... | ... | ... | ... | <i>Skusea</i> |
| Scutellum with scales of both shapes | ... | ... | ... | ... | ... | ... | ... | <i>Leptosomatomyia</i> |

3. Hypopygium without definite claspettes, though often with more or less modified basal plaques 4
Hypopygium with definite claspettes bearing an appendage, which is usually flattened but may be merely setiform 8
4. Clasper with a row of teeth *Armigeres*
Clasper without a row of teeth 5
5. Palpi with only one terminal segment *Banksinella*
Palpi with two distinct terminal segments 6
6. Spine of clasper terminal 7
Spine of clasper subterminal *Aëdimorphus*
7. Conspicuously ornamented species; phallosome divided, each half spiny on the outer side; palpi bare, upturned *Stegomyia*
Dark species with little ornamentation; phallosome undivided and smooth; palpi hairy, not upturned at tip *Pseudoskusea*
8. Side-pieces of hypopygium with well-marked basal lobes *Ochlerotatus*
Side-pieces without basal lobes, at most with an aggregation of hairs 9
9. Claspettes connected with the side-pieces, appendage distinctly articulated *Finlaya*
Claspettes free, appendage not distinctly articulated *Macleaya*

Females.

1. Wings with a tuft of very long scales at the extreme base *Chaetocruiomyia*
Wings without such scale-tuft 2
2. Cerci short, eighth segment not completely retracted 3
Cerci long, eighth segment small and retracted; head with many narrow scales above 11
3. Eighth sternite large and exerted; head usually with many narrow scales above 4
Eighth sternite smaller and partly retracted; head with few or no narrow scales above 5
4. Lower mesepimeral bristles absent *Finlaya*
Some of these bristles present *Pseudoskusea*, part
5. Strongly ornamented species 6
Dark species with little ornamentation 8
6. Claws toothed, clypeus scaly *Stegomyia*, part
Claws simple, clypeus bare 7
7. Scutum with a median silvery-white line *Stegomyia*, part
Scutum without such line *Macleaya*
8. Scutellum with broad flat scales 9
Scutellum with narrow scales 10
9. Claws toothed; proboscis rather stout *Armigeres*
Claws simple; proboscis more slender *Skusea*
10. Claws toothed *Aëdes*, part
Claws simple *Aëdes*, part; *Pseudoskusea*, part
11. Lower mesepimeral bristles present *Ochlerotatus*, part
Lower mesepimeral bristles absent *Ochlerotatus*, part; *Aëdimorphus*; *Banksinella*

Subgenus *Chaetocruiomyia*, Theo.

This subgenus is very well characterised by the basal scale-tuft on the wings. When males and larvae are discovered some characters may be found which will necessitate re-erecting it to full generic rank, but the females, which alone are known at the present time, show no structural differences from *Aëdes*.

Aedes (Chaetocruimyia) spinosipes, Edw.

Aedes (Chaetocruimyia) spinosipes, Edwards, Bull. Ent. Res. xiii, p. 92 (1922).
Chaetocruimyia sylvestris, Theobald, Mon. Cul. v, p. 196 (1910) (preoccupied).

A small, very stoutly built species; the scutum with a large whitish-ochreous patch in front; hind tarsi with white rings at the bases of the first two segments, third and fourth black, fifth white.

QUEENSLAND: Kuranda (*Bancroft*); Palm Island (*Hill*); Innisfail (*Taylor*).

Aedes (Chaetocruimyia) humeralis, Edw.

Aedes (Chaetocruimyia) humeralis, Edwards, Bull. Ent. Res. xiii, p. 93 (1922).

Differs from *A. spinosipes* in having the pale patch on the scutum divided by a dark median stripe. The third hind tarsal segment has a distinct white ring; the species has a rather strong superficial resemblance to *A. (Macleaya) tremula*, Theo.

QUEENSLAND: Brigalow Scrub and Eidsvold (*Bancroft*).

Subgenus **Stegomyia**, Theo.

Three species of this subgenus have been reported from the region, only one of which is truly endemic. In view of the rather large number of species in the Oriental region, the paucity of species in the Australasian region is somewhat surprising.

Aedes (Stegomyia) argenteus (Poiret) (Stegomyia fasciata).

Culex bancrofti, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1740 (1889).

The yellow-fever mosquito is widely spread in the warmer parts of the region. In Australia it may have been comparatively recently introduced, as it occurs only in the coast towns; according to Cleland it is found all along the Queensland coast and extends into the northern coast towns of New South Wales, but records from further south (Newcastle and Victoria) probably rest on a confusion with *A. notoscriptus*. It is known from Celebes, Papua, New Caledonia, Fiji, Samoa, Sandwich Is. and Pitcairn I., but is apparently absent from New Zealand and also from many of the smaller Pacific islands.

Aedes (Stegomyia) albopictus (Skuse).

Culex albopictus, Skuse, Ind. Mus. Notes, iii, p. 5 (1895).

Stegomyia scutellaris, Theobald (*nec* Walker), Mon. Cul. i, p. 298 (1901).

I have seen no Australasian examples of this abundant Oriental species, but the following records of its occurrence within the region have been published. It is not impossible that some of them may refer to *A. variegatus*.

TIMOR GROUP: Timor, Alor and Saparoea (*Brug, Haga*); Sumba (*Schuurmans Stekhoven*). PAPUA: Dutch region (*Brug, Haga*); ex-German region (*Theobald*); Lakekamu (*Giblin*). N. AUSTRALIA: Darwin (*Hill*); Moa Island (*Luscombe*).

Aedes (Stegomyia) variegatus (Dol.).

Culex variegatus, Doleschall, Nat. Tijd. Ned. Ind. xvii, p. 77 (1858).

Culex scutellaris, Walker (*nec* Theobald), Proc. Linn. Soc. iii, p. 77 (1859).

Culex zonatipes, Walker, Proc. Linn. Soc. v, p. 229 (1861).

Stegomyia sp., Laveran, C.R. Soc. Biol. liv, p. 909 (1902).

Stegomyia pseudoscutellaris, Theobald, Entom. xliii, p. 156 (1910).

Although superficially very similar to the preceding, this is really very distinct in the following particulars: (1) the central silvery stripe of the scutum is of perfectly even width, not slightly widened anteriorly; (2) there is a distinct patch of flat silvery

scales close above the root of the wing, which is absent in *A. albopictus*; (3) the silvery scales of the scutellum form a straight transverse line, the apical part of the median lobe being bare, whereas in *A. albopictus* the scutellum is completely covered; (4) the scales of the pleura are not arranged in irregular patches, but form two well-marked lines, one just below the margin of the scutum, the other across the middle; (5) the lateral white markings of the abdomen are entirely removed from the bases of the tergites, and somewhat crescent-shaped, while in *A. albopictus* each tergite has two disconnected white spots on each side, the upper of which is quite basally placed; finally (6) there are well-marked structural differences in the hypopygium.

According to O'Connor the larvae are found chiefly in old coconut husks and cacao pods.

This species has a very wide distribution within the region, but seems most abundant on the smaller islands; it occurs as far west as Christmas Island (S. of Java, its only known place of occurrence within the Oriental region) and as far to the north-east as the Tokelau Islands. It occurs widely in Papua and is abundant in Fiji, but has not yet been recorded and may be absent from the mainland of Australia, New Caledonia, the Solomon Is., Celebes, Timor and New Zealand. Some new records are: BURU (*Toxopeus*). FIJI GROUP: Loma-Loma, Nukulau, Savu-Savu, Waievo, Wailagilala (C. L. Edwards). TONGA Is.: Nukualofa and Vavau (C. L. Edwards). NEW BRITAIN: Rabaul (Hill). NEW HEBRIDES: Zagabé (specimen in British Museum, received for determination from the French Government); Port Sandwich, Mallicolo I. (*Laveran*).

Subgenus *Banksinella*, Theo.

This subgenus is founded principally on the structure of the male palpi, which are longer than the proboscis, and apparently composed of only two segments, of which the apical one is turned upwards. The remaining characters seem to show most affinity with the subgenus *Aëdimorphus*. Two species are known to occur in the Australasian region.

Aëdes (*Banksinella*) *lineatopennis* (Ludlow).

Taeniorhynchus lineatopennis, Ludlow, Can. Ent. xxxvii, p. 133 (1905).

Banksinella luteolateralis, Theobald, *partim*.

Pseudohowardina linealis, Taylor, Rept. for 1911, Austr. Inst. Trop. Med., p. 10 (1913).

Readily known from the following by the broad margin of yellow scales on the scutum, yellow scales on some of the veins, and the dark tarsi. The somewhat similar *A. (Skusea) aurimargo* is distinguished by its dark wing-scales, simple female claws, etc.

QUEENSLAND: Ching Do and Townsville (Taylor). Also widely spread in the Oriental and Ethiopian regions.

Aëdes (*Banksinella*) *brugi*, sp. n.

♂. Head clothed with narrow ochreous scales above, the usual broad flat whitish scales at the sides. Antennal torus ochreous, flagellum dark. Palpi and proboscis dark-scaled. Palpi nearly one-third longer than the proboscis, the single terminal segment turned upwards and with long spreading hairs as in the other members of the subgenus. Thorax with the integument reddish brown, scutellum lighter. Scales of scutum, scutellum, pronotal lobes and proepimeral narrow, curved, dark or light brownish. Pleura with some patches of white flat scales. No lower mesepimeral bristles. Abdomen dark brownish above, with a distinct creamy-white basal band on each segment; venter mostly creamy-white. Hypopygium small. Ninth tergite

apparently completely divided into two portions, each with a thumb-like projection. Side-pieces not longer than broad, with a rather large hairy basal lobe. Claspers forked, both prongs blunt-ended and somewhat curved, the shorter one with a few bristles but without a distinct spine. *Legs* dark brown, femora light beneath but not mottled; hind femora with a dark dorsal line extending almost to the base; tarsi damaged, but the first three segments of the front and at least the first two of the hind tarsi with narrow basal creamy-white rings. *Wings* very scantily scaled, the scales all dark. Fork-cells as long as their stems; cell *Ri* distinctly contracted just before the tip. Wing-length 3.8 mm.

S. PAPUA: Merauke, 1922 (*Dr. S. L. Brug*). Type male presented to the British Museum by the collector.

Although the male palpi are quite typical of the subgenus, the nearly bare wings suggest the genus *Mimomyia*, from which, however, the species is quite definitely excluded by the rather numerous postspiracular bristles. The hypopygium is very peculiar and distinctive, quite unlike that of any of the African species.

Subgenus *Aëdimorphus*, Theo.

Only two Australasian species can be referred to here with any certainty, neither of them being endemic to the region. Possibly some of the species placed under *Ochlerotatus* should be included here.

Aëdes (*Aëdimorphus*) *alboscuteellatus* (Theo.).

Lepidotomyia alboscuteellata, Theobald, Ann. Mus. Nat. Hung. iii, p. 80 (1905).

Reedomyia pampangensis, Ludlow, Can. Ent. xxxvii, p. 94 (1905).

Easily known from all other Australian species of *Aëdes* by the flat silvery-white scales of the scutellum and the entirely dark tarsi. The male has not yet been found in Australia, but as the species is very widely distributed in the Oriental region, the determination is probably correct.

NORTHERN TERRITORY: Daly River and Doctor's Gully (*Hill*).

Aëdes (*Aëdimorphus*) *vexans*, Mg.

Culex vexans, Meigen, Syst. Besch. vi, p. 241 (1830).

Ochlerotatus vexans (Mg.) Edwards, Bull. Ent. Res. vii, p. 218 (1917).

Culex nocturnus, Theobald, Mon. Cul. iii, p. 159 (1903).

? *Culex nocturnus* var. *niger*, Theobald, Nova Caledonia, i, p. 164 (1913).

Aëdes (*Ochlerotatus*) *vigilax*, Edwards (*nec* Skuse), Bull. Ent. Res. xiii, p. 99 (1922).

I consider, after a close examination, that my first opinion as to the identity of *C. nocturnus* is more likely to be correct, and do not understand why I proposed to alter it. The two species (*vexans* and *vigilax*) are certainly similar, but seem well distinguished by the characters of the proboscis; also, of course, by the male hypopygium. Males of *A. vexans* have not yet been obtained in the Australasian region, so that there is still an element of doubt in the determination.

FIJI (*Hall*). TONGA IS.: Nukualofa (*C. L. Edwards*). NEW CALEDONIA: Houailou (*Montague*). SAMOA (*O'Connor*). DUTCH E. INDIES: Celebes, Ternate (*Brug*). Also occurs throughout the Oriental, Palaearctic and Nearctic regions.

Subgenus *Ochlerotatus*, Arrib.

The Australasian species of this subgenus are rather numerous, and may be divided into two groups: firstly, those which possess at least one lower mesepimeral bristle, and secondly, those in which the lower mesepimeral bristles are absent.

The members of the first group are the more typical representatives of the subgenus, and show little or no divergence in structure from the holarctic forms. In this group there are only three Australian species which have ringed tarsi: *A. vittiger* (Skuse), *A. vandema* (Strick.) and *A. camptorhynchus* (Thomson), all very well characterised forms. The remaining species, with the possible exception of *A. stricklandi* (Edw.), have the tarsi dark; these are *A. nigrithorax*, Macq. (*tasmaniensis* Strick.), *A. cunabulanus*, sp. n., *A. australis* (Theo.), *A. wilsoni* (Taylor), *A. burpengaryensis* (Theo.) and probably the allied species mentioned below which have not been examined by the author. All these have one strong and 1-3 weaker lower mesepimeral bristles, with the exception of *A. stricklandi* (Edw.) which has only a single rather weak bristle in this position. The hypopygium of those species of which the male is known has a more or less distinct apical lobe to the side-piece.

In the second group, without lower mesepimeral bristles, all the species have ringed tarsi. Apart from *A. aculeatus* (Theo.), which is peculiar in its thoracic scaling, they are all rather alike. *A. flavifrons* (Skuse), *A. theobaldi* (Taylor) and *A. normanensis* (Taylor) all have a distinct sprinkling of pale scales on the wings; of the remaining species, in which the wing-scales are all dark, *A. vigilax* (Skuse), *A. rubrithorax* (Macq.) and *A. albirostris* (Macq.) have the proboscis pale in the middle beneath, while *A. antipodeus* (Edw.) and *A. imprimens* (Walk.) have it entirely dark-scaled. In this group I have only seen males of *A. normanensis*, *A. vigilax*, *A. rubrithorax* and *A. antipodeus*. In all of these the apical lobe of the side-piece is absent, the basal lobe large, the claspette small with an almost bristle-like appendage. This is the structure characteristic of the group of South American species, including *A. taeniorhynchus* (Wied.) and its allies, which Dyar has proposed to treat as a distinct subgenus (*Culicelsa*). It hardly seems to me, however, that the structural difference is sufficient to warrant this. Some of the species included here may possibly be found to belong to *Aedimorphus* when males are discovered.

I. Tarsi with pale rings.

Aedes* (*Ochlerotatus*) *vittiger (Skuse).

Culex vittiger, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 172S (1889).

Culicada vittiger, Cooling, Ann. Rept. Com. Pub. Health Queensland, p. 63 (1913).

An extremely distinct species on account of the ornamentation of the thorax, which is clothed with pale ochreous scales, with four sharply defined lines of black scales. It differs from the other ringed-legged species of the subgenus in having the first hind tarsal segment dark at the tip only, instead of with a narrow pale ring at the base. The male has been described by Cooling, and appears to be remarkable in having the claspettes forked.

Cooling also describes the larvae, which have two strong spines beyond the pecten-tuft and live in temporary ground pools. Bancroft states that the eggs are studded with papillae, presumably as in the genus *Psorophora*.

QUEENSLAND: Port Denison and Wide Bay (*Masters*); Burpengary (*Bancroft*); Brisbane (*Wesché*); Townsville and Cardington (*Taylor, Hill*). NEW SOUTH WALES: Gosford (*Skuse*); Narromine (*Ferguson*).

Aedes* (*Ochlerotatus*) *aculeatus (Theo.).

Gilesta aculeata, Theobald, Mon. Cul. iii, p. 233 (1903).

Another very well-defined species, with the head and sides of the mesonotum clothed with small flat yellow scales, and the cross-veins practically in one line. The reference to the subgenus *Ochlerotatus* is provisional, pending the discovery of the male.

QUEENSLAND: Deception Bay (*Bancroft*).

Aedes (Ochlerotatus) vandema (Strickland)

Culicada vandema, Strickland, Entom. xlv, p. 202 (1911).

Culicada vandema var. *variegatans*, Strickland, *ibid.*, p. 204.

This also could hardly be confused with any other Australian species on account of the conspicuous brown blotch on the membrane across the middle of the wing. Traces of such a blotch are sometimes seen in *A. (F.) queenslandis*, from which *A. (O.) vandema* differs in the subgeneric characters.

TASMANIA: locality unstated (*Bancroft*); Wedge Bay and Mt. Arthur (*Littler*).

Aedes (Ochlerotatus) camptorhynchus (Thomson).

Culex camptorhynchus, Thomson, Eugenie's Resa, Dipt., p. 443 (1868).

Culex labeculosus, Coquillett, Ent. News xvi, p. 116 (1906).

Culicelsa westralis, Strickland, Entom. xlv, p. 131 (1911).

Culicada inornata, Strickland, Entom. xlv, p. 201 (1911).

Culicada nigra, Taylor, Trans. Ent. Soc. 1913, p. 688 (1914).

Culicada annulipes, Taylor, Trans. Ent. Soc. 1913, p. 693 (1914).

? *Culicada victoriensis*, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 460 (1914).

Though at first sight rather similar to several other Australian species, this is really very distinct by the combination of white-ringed tarsi with the presence of well-developed lower mesepimeral bristles. The only other species in the Australian fauna which possess both these characters are *A. vittiger* and *A. vandema*, the first very distinct by its thoracic markings and the second by the large brown patch on the wing-membrane. For the rest, *A. labeculosus* may be known by the reddish thorax, conspicuously mottled femora and tibiae, and white-scaled venter, usually with a median row of rounded dark spots.

Thomson's type, which I have examined in the Stockholm Museum, although damaged, is quite recognisable as this species. I did not note the occurrence of lower mesepimeral bristles, but am indebted to Dr. Y. Sjöstedt for confirming their presence.

I have not examined the type of *C. victoriensis*, but cannot separate it from *A. labeculosus* by Taylor's description. Of the rest of the synonymy given above there can be no doubt.

NEW SOUTH WALES: Milson I. (*Cleland*). VICTORIA: Beaconsfield (*Hill*); Melbourne (*Cumpston*). TASMANIA: Georgetown, Launceston and St. Helens (*Littler*); Cataract Gorge, Launceston (*C. L. Edwards*). FLINDERS I. (*Cleland*). SOUTH AUSTRALIA: Adelaide and Tailem Bend (*Cleland*). WEST AUSTRALIA: Perth (*Cleland*).

Aedes (Ochlerotatus) flavifrons (Skuse).

Culex flavifrons, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1735 (1889).

Culicada flavifrons, Taylor, *ibid.* xxxviii, p. 751 (1914).

This is unknown to me. From Skuse's description it must resemble *A. camptorhynchus* rather closely, except that the wings have a few scattered yellowish scales. As there are no pale scales on the wings of any *A. camptorhynchus* which I have examined, I do not think it can be the same species. Theobald's *C. flavifrons* is evidently a distinct species, as pointed out by Taylor, differing in the darker thoracic integument and broader wing-scales.*

NEW SOUTH WALES: Blue Mts. (*Masters*). QUEENSLAND: Brisbane (*Tryon*).

* Dr. Ferguson has re-examined Skuse's type and states that lower mesepimeral bristles are present; pale scales of wings moderately numerous and slightly broader and shorter than usual, but not nearly so wide as in *A. theobaldi*.

***Aedes (Ochlerotatus) theobaldi* (Taylor).**

Grabhamia flavifrons, Theobald (*nec* Skuse), Mon. Cul. iv, p. 304 (1907).

Grabhamia theobaldi, Taylor, Proc. Linn. Soc. N.S.W. xxxviii, p. 751 (1913) and xliii, p. 832 (1919).

A rather small dark-coloured species, with rather numerous pale scales scattered over the wings, these pale scales being quite broad and square-ended. The femora (though not the tibiae) are also conspicuously mottled with pale scales. According to Taylor's figure the male hypopygium is very similar to that of *A. vigilax*, but quite distinct from that of *A. normanensis*.

QUEENSLAND: Deception Bay, etc. (*Bancroft*). VICTORIA: Bamawm, Kyabram, Mildura and Echuca (*Taylor*).

***Aedes (Ochlerotatus) normanensis* (Taylor).**

Culex normanensis, Taylor, Proc. Linn. Soc. N.S.W. xl, p. 182 (1915).

Rather closely resembles the preceding, differing in the somewhat narrower tarsal rings and in having the pale scales on at least the apical half of the wing much narrower and more pointed. It is possible that this may be the same as *A. flavifrons* (Skuse).

QUEENSLAND: Normanton (*Taylor*).

***Aedes (Ochlerotatus) vigilax* (Skuse).**

Culex vigilax, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1731 (1889).

Culex marinus, Theobald, Mon. Cul. i, p. 396 (1901).

Culex procax, Theobald (*nec* Skuse), *ibid.*, p. 415.

Culex albirostris, Theobald (*nec* Macquart), Mon. Cul. iii, p. 162 (1903).

? *Culicelsa pseudovigilax*, Theobald, Mon. Cul. iv, p. 382 (1907).

Culicelsa uniformis, Strickland, Entom. xlv, p. 131 (1911).

Fairly readily distinguishable from related species by the dark, almost black thoracic integument. From *A. (Aedimorphus) vexans*, Mg. (a species which has not yet been reported from the Australian continent, though very likely occurring there) it differs in the rather longer proboscis, which on the underside shows a rather sharp line of demarcation between the pale middle part and the blackish apical third, also in the pale bands of the abdomen, which are straight and not indented in the middle as is usually the case in *A. vexans*.

A common salt-marsh species round the Australian coasts, and occurring also in Papua, Timor, Celebes, the Philippine Is., Formosa and Siam. Apparently not yet reported from Victoria or Tasmania, but occurring in West Australia at Perth.

***Aedes (Ochlerotatus) rubrithorax* (Macq.).**

? *Culex rubrithorax*, Macquart, Dipt. Exot. 4th Supp., p. 9 (1850).

Culex rubrithorax, (Macquart) Theobald, Mon. Cul. I, p. 416 (1901).

? *Culex occidentalis*, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1729 (1889).

? *Culex procax*, Skuse, *ibid.*, p. 1742.

A rather small species of the size and build of *A. vigilax*, to which it is evidently allied, though easily distinguished by the reddish thorax and absence of pale mottling on the femora. The tendency of the lateral white areas of the abdominal tergites to be produced dorsally in the middle of the segments is not nearly so great as in *A. vigilax*.

For convenience Theobald's interpretation of Macquart's name may be followed, but its correctness is very doubtful, since the insects do not conform in all respects to the original description, and no specimens of this species have been taken in recent years in Tasmania.

Skuse described *C. occidentalis* from a single female from Western Australia. It may prove to be a distinct species, but there is nothing definite in the description which disagrees with the British Museum specimens of *A. rubrithorax*. Theobald's identification of *C. occidentalis* was almost certainly an error; Skuse describes the venter as white, the segments with a narrow apical brown band, a description which would apply well to *A. rubrithorax* but certainly not to *A. queenslandis*. Skuse's description of *C. procax* also agrees with this species, and though there are some discrepancies in Taylor's redescription of the type (for example, he describes the narrow scales of the head as white, while Skuse calls them golden), I think there can be little doubt of the identification.*

QUEENSLAND: Moreton Bay (*Bancroft*). NEW SOUTH WALES: Gosford and South Clifton (*Skuse*); Bulli (*Taylor*). TASMANIA (*Macquart*). WEST AUSTRALIA: King George's Sound (*Masters*).

***Aëdes (Ochlerotatus) albirostris* (Macq.).**

Culex albirostris, Macquart, Dipt. Exot. Supp. iv, p. 10 (1850).

A female specimen in the British Museum, probably of this species, shows the following characters:—Head with ochreous scales in the middle and round the eyes, surrounding a pair of patches of darker scales. Proboscis largely clothed with whitish scales, especially in the middle, but leaving the base and the apical fourth dark. Palpi narrowly white at the tip and at each joint. Thoracic integument reddish-brown, darker above. Proepimera with narrow ochreous scales above, flat black and white ones below. Mesonotal scales all narrow, reddish brown in the middle, lighter at the sides; no distinct markings. No lower mesepimeral bristles. Abdomen blackish, with narrow white bands which are mainly basal but spread on to the apical margin of the last four segments. Cerci long. All the femora largely pale-scaled, except towards the tips; the anterior pairs with scattered dark scales in front and more especially above. Tibiae and tarsi dark; first two segments of the front tarsi, three of the middle and four of the hind tarsi narrowly ringed with white at the base; remaining segments all dark. Claws all toothed. Wing-scales all dark.

Macquart's description differs in some respects; according to him the abdomen has white bands on the posterior borders of the segments; the hind tibiae are a little whitish in the middle (perhaps merely rubbed), and there is a white ring at the base of each tarsal segment.

NEW ZEALAND: Akaroa (*Macquart*); Invercargill (*Wesche*).

***Aëdes (Ochlerotatus) antipodeus*, Edw.**

Ochlerotatus antipodeus, Edwards, Bull. Ent. Res. x, p. 132 (1920).

Very distinct from *A. albirostris* (Macq.), the only other New Zealand species of the subgenus, by the entirely black-scaled proboscis and the conspicuous thoracic ornamentation, which suggests a species of *Finlaya*, such as *A. (F.) lawriei* (Carter); this ornamentation, however, is only seen in good specimens. The proepimera are clothed with small flat black scales only; no lower mesepimeral bristles. Hypopygium in most respects very similar to that of *A. vigilax*, with a large basal but no apical lobe to the side-piece, and an almost bristle-like appendage to the claspette.

NEW ZEALAND: Karikari Bay, Auckland (*Brookes*); Te Horo, Wellington; Ohakune (*Harris*); Kaitaia, Russell and Whangaroa (*Miller*); New Brighton (*Campbell*).

* Dr. Ferguson informs me that the type of *C. procax* apparently possesses a lower mesepimeral bristle; it is therefore more likely to be *A. camptorhynchus* than *A. rubrithorax*. He also states that the type of *A. occidentalis* is a *Finlaya*.

Aedes (Ochlerotatus) imprimens (Walk.).

Culex imprimens, Walker, Proc. Linn. Soc. v, p. 144 (1861).

Ochlerotatus imprimens, Edwards, Bull. Ent. Res. iv, p. 228 (1913).

This is quite distinct from the other Australasian species by the uniformly black-scaled proboscis, and the absence of definite ornamentation on the thorax, the latter feature distinguishing it from *A. antipodeus*. The male is still unknown, so that its location in *Ochlerotatus* rather than *Aëdimorphus* is a matter of conjecture.

AMBOINA (Walker). SOLOMON IS. : Guadalcanar (Dr. A. G. Carmant). PAPUA : Merauke (Brug). Also Oriental.

II. *Tarsi without pale rings.***Aedes (Ochlerotatus) stricklandi**, Edw.

Grabhamia australis, Strickland, Entom. xlv, p. 133 (1911) (*nec C. australis*, Erichs.).

Ochlerotatus stricklandi, Edwards, Ann. Mag. Nat. Hist. (8) ix p. 523 (1912).

Grabhamia flindersi, Taylor, Trans. Ent. Soc. 1913, p. 686 (1914).

A rather large and very distinct species, the deep chocolate-brown scales of the whole mesonotum and proepimera contrasting strongly with the rather dense covering of white scales on the pleura. The types of both *G. australis* and *G. flindersi* have lost their hind legs, so that it is uncertain whether the species should be placed in the dark-legged or the ringed-legged section of the subgenus; the anterior tarsi show only faint traces of pale rings at the bases of the segments. The wings differ from those of all the dark-legged species in having a distinct speckling of pale scales.

Strickland's name cannot be used for the species, for although Erichson's *C. australis* is unrecognisable and may not be an *Aedes*, Theobald's identification of Erichson's species (now regarded as probably erroneous) prevents the subsequent use of this name within the genus.

WESTERN AUSTRALIA : Darling Range, Perth (Cleland). FLINDERS ISLAND (Cleland).

Aedes (Ochlerotatus) nigrithorax (Macq.).

Culex nigrithorax, Macquart, Dipt. Exot. Supp. ii, p. 9 (1847).

Andersonia tasmaniensis, Strickland, Entom. xlv, p. 250 (July 1911), *nec*

Culicada tasmaniensis, Strickland, Entom. xlv, p. 181 (May 1911).

Menolepsis ? *tasmaniensis*, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 466 (1914).

A large species, easily known from all the other species with dark tarsi by the patch of broad flat white scales in front of the root of each wing. The femora, and to a less extent the tibiae, are mottled with dark and light scales; on the hind femora the dark scales are quite numerous over almost the whole of the anterior surface. The abdomen is unbanded, without a distinct purple gloss. The scales on the anterior part of the mesonotum are dark brown in the middle and usually golden at the sides, but a specimen taken by my father on the summit of Cradle Mt. has the lateral scales almost pure white, and may possibly represent a distinct variety or species. Taylor's type of *M. tasmaniensis* only differs in possessing a few scales on the end of the postnotum; although these scales seem to be in their natural position I do not think there can be two species concerned.

I am indebted to Mr. J. E. Collin for the loan of the type of Macquart's *C. nigrithorax*, which still exists in Bigot's collection. It is in extremely bad condition, but is recognisable as an *Ochlerotatus* with dark tarsi, and from its size, and the apparent presence of a flat white scale above one of the wing-roots, is almost certainly this species. I propose to adopt the name, since otherwise a new one will be required, Strickland's *A. tasmaniensis* being preoccupied by his own *Culicada tasmaniensis*.

The hypopygium, which I have mounted, shows the following characters: Side-pieces with the basal lobes well developed, hairy; apical lobe slight, bearing two or three rather stout curved spines. Claspers with the basal two-thirds somewhat swollen, apical third slender, terminal spine long. Claspettes with a sub-basal thumb on the inner side bearing a small terminal bristle, somewhat as figured by Cooling for *A. vittiger*; appendage broad and flat, with a retrorse angle at the base. Lobes of ninth tergite each with about six short bristles. This structure is almost identical with that of *A. burpengaryensis*, Theo., which chiefly differs in having the spines on the apical lobe of the side-piece more slender, and the sub-basal thumb of the claspettes rather shorter. It is evident that all the dark-legged species of this group are very closely related, and are probably to be regarded as geographical representatives of a single type.

TASMANIA: localities unstated (*Macquart, Anderson*); Wedge Bay (*Littler*); Cradle Mt. (*C. L. Edwards*).

***Aedes (Ochlerotatus) cunabulanus*, sp. n.**

Culex frenchi, Strickland (*nec* Theo.), Entom. xlv, p. 180 (1911).

Very similar to *A. (O.) nigrithorax*, but much smaller, and lacks the broad white scales in front of the wing-bases; mesonotal scales mostly golden brown, without darker median band; abdominal segments 2-5 more or less distinctly banded with white at the base; and there are apparently no flat black scales on the proepimera, though this may perhaps be due to denudation. As in *A. nigrithorax*, the integument of the thorax (of the female) is reddish; the abdomen and legs without obvious purple reflections; cerci elongate; venter white-scaled; femora mottled, the dark scales numerous all over the anterior surface of the hind femora.

TASMANIA: Cradle Valley, 20.1.1923 (*C. L. Edwards*), type ♀; locality unstated (*Bancroft*), 5♀, all much damaged.

Aedes (Ochlerotatus) wilsoni* (Taylor).

Culicada wilsoni, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 833 (1919).

This differs from all the other dark-legged species of the subgenus known to me by the blackish integument of the thorax. The palpi are rather short and unusually stout. Proepimeral scales all rather narrow and loosely applied, mostly dark brown. Abdomen conspicuously banded, without the least trace of purple sheen on the dark parts. Femora and tibiae, and also the first tarsal segments, conspicuously powdered with ochreous-white scales; on the whole of the outer surface of the hind femora the light scales are more numerous than the dark, though there are some scattered dark scales even on the basal half. The pleural scales are ochreous white and cover most of the pleura, except for the lower part of the sternopleurite.

VICTORIA: Kyabram, Echuca, Bamawn, Swan Hill and Mildura (*Taylor*).

***Aedes (Ochlerotatus) sagax* (Skuse).**

Culex sagax, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1744 (1889).

I do not know this species. According to Skuse's description it has the integument of the thorax "deep brown or pitchy black." In this and many other respects it seems to be similar to *A. wilsoni*, but can hardly be the same, as Skuse states that the pleurae are "spotted with small patches of white scales"; the abdomen covered with violet black scales; and the femora and tibiae covered with violet-black scales "more or less dusted with pale ochreous."

NEW SOUTH WALES: Murrumbidgee (*Stephens*).

* Dr. Ferguson believes that *A. wilsoni* and *A. sagax* are certainly conspecific, but *sagax* has the abdominal scales distinctly purplish in certain lights.

Aedes (Ochlerotatus) australis (Theo.).

Culex australis, Theobald, Mon. Ent. ii, p. 91 (1901).

? ? *Culex australis*, Erichson, Arch. Naturg. viii, p. 470 (1842).

Differs from *A. nigritorax*, *A. cunabulanus* and *A. wilsoni* in having the basal two-thirds of the outer surface of the hind femora entirely pale, the outer third dark, with some scattered pale scales; knee-spot conspicuous, yellowish. Besides this, the dark scales of the abdomen and legs have a very pronounced purple or violet gloss. The four anterior femora are conspicuously speckled in front, the tibiae less so. Proepimeral scales all rather narrow and all pale.

Erichson's *Culex australis* can hardly be this species, because he mentions a white tip to the tibia as well as to the femur, while in the present form the tibiae are dark at the tips. Moreover, although the male of this species is unknown to me, I consider it unlikely that it has the palpi shorter than the proboscis, such a condition being unknown in the restricted subgenus *Ochlerotatus*. I cannot, however, suggest what Erichson's species might have been.

In many respects this answers to Skuse's and Taylor's description of *A. sagax*, but the thorax integument is conspicuously reddish and the hind claws are toothed.

The larvae were found by Dr. Cleland in temporary snow-pools at a height of 6,000 ft.

VICTORIA: Marysville and Mt. Bismarck (*Bancroft*). NEW SOUTH WALES: Mt. Kosciusco (*Cleland*).

Aedes (Ochlerotatus) clelandi (Taylor).

Culicada clelandi, Taylor, Trans. Ent. Soc. 1913, p. 690 (1914).

Very closely related to *A. australis*, but the four anterior femora dark in front, without scattered pale scales.

FLINDERS ISLAND (*Cleland*).

Aedes (Ochlerotatus) burpengaryensis (Theo.).

Culex burpengaryensis, Theobald, J. Econ. Biol. i, p. 27 (1905).

Evidently closely related to *A. australis* and *A. clelandi*, differing from the former in the absence of pale speckling on the anterior femora, and from both in its smaller size and unbanded abdomen.

Reared from larvae found in a well.

QUEENSLAND: Burpengary (*Bancroft*).

Subgenus **Finlaya**, Theobald.

In this subgenus, in spite of great diversity of ornamentation, there is a remarkable uniformity of structure. The twenty Australasian species already known conform well to my definition of the subgenus, and fall so readily into groups that their identification is a fairly easy matter. All of them possess white rings on the hind tarsi, which are situated mainly or entirely at the bases of some or all of the segments.

The following six groups may be recognised:—

1. Species with spotted wings and numerous pale rings on the femora and tibiae; scales of the head and scutellum mostly broad and flat: *A. kochi* (Dön.) and *A. poicilia* (Theo.).

2. Rather large species with two large patches of white scales on the scutum; proepimera and scutellum with rounded white scales only; head scales mostly narrow: *A. purpureus* (Theo.), *A. priestleyi* (Taylor) and *A. pecuniosus*, Edw.

3. With a large patch or a broad median stripe of white or golden scales on the front half of the scutum; scales on top of head and on scutellum narrow; *A. australiensis* (Theo.), *A. auridorsum*, Edw., *A. papuensis* (Taylor), *A. biocellatus* (Taylor), *A. albitarsis* (Taylor) and *A. palmarum*, sp. n.

4. With sharply defined white or golden lines on the scutum and conspicuous white lines on the femora and tibiae; scutellar scales flat; head scales nearly all flat: *A. notoscriptus* (Skuse) and *A. pulcherrimus* (Taylor).

5. With more or less well-defined golden lines on the scutum, but without white lines on the femora and tibiae; with a large area of narrow scales: *A. aureostriatus* (Dol.), *A. quinquelineatus*, Edw., *A. lauriei* (Carter) and *A. quasirubri thorax* (Theo.).

6. Scutum without special ornamentation; scales on top of head and on scutellum all narrow; white rings on hind tarsi broad: *A. alboannulatus* (Macq.), *A. queenslandis* (Strick.) and *A. milsoni* (Taylor).

***Aedes* (Finlaya) *poicilia*, Theo.**

Finlaya poicilia, Theobald, Mon. Cul. iii, p. 283 (1903).

This is probably to be regarded as the Oriental representative of *A. (F.) kochi*, with which it agrees structurally, differing only in the much darker thoracic integument, which is blackish instead of rather light brown, and in having all the pale markings of the legs and wings pure white; the white markings of the wings occur in much smaller spots than is usual in *A. kochi*.

Although recorded by Bancroft and Taylor from several localities in Australia and Papua it seems not improbable that these records really refer to *A. kochi*.

***Aedes* (Finlaya) *kochi* (Dön.).**

Culex kochi, Dönitz, Insekten Börse, v, p. 38 (1901).

Finlaya samoana, Grünberg, Ent. Rundschau, xxx, p. 130 (1913).

This is the type of the subgenus; it is unmistakable on account of the elaborate adornment of the wings and legs. The pale markings of the wings are very variable in extent, though usually almost as extensive as the dark areas, and always more or less tinged with yellow, especially towards the costa. Many of the pale areas on the femora and tibiae are also strongly tinged with yellow. The hypopygium differs from that of the other Australasian species in possessing a tuft of very long scales in the middle of the inner margin of the side-piece.

PAPUA (Dönitz). SAMOA (Grünberg, O'Connor).

***Aedes* (Finlaya) *pecuniosus*, Edw.**

Aedes (Finlaya) *pecuniosus*, Edwards, Bull. Ent. Res. xiii, p. 94 (1922).

Perhaps the most beautiful and highly ornamented of all the Australian species of this subgenus. Though closely related to the two following, it appears to be sufficiently well distinguished by the possession of a double median row of flat silver scales on the mesonotum, as well as in some other details. The African species *A. (F.) longipalpis*, Grünb., and *A. (F.) fulgens*, Edw., have a similar thoracic ornamentation, and it is curious also to note that in two other quite distinct genera (*Harpagomyia* and *Topomyia*) a silvery thoracic stripe may be present or absent in closely allied species.

NORTHERN TERRITORY: Port Darwin (C. L. Strangman).

Aedes (Finlaya) purpureus (Theo.).

Molpemyia purpurea, Theobald, Mon. Cul. v, p. 479 (1910).

Similar to the last species in most respects, including the leg-markings, but differing in the absence of the median silvery stripe and in some other details of ornamentation of the mesonotum.

N. QUEENSLAND: Stannary Hills (*Bancroft*).

Aedes (Finlaya) priestleyi (Taylor).

Calomyia priestleyi, Taylor, Trans. Ent. Soc. London, 1913, p. 684 (1914).

Evidently closely similar to *A. (F.) purpureus*, but according to Taylor's description it differs somewhat in the markings of its abdomen and tarsi.

QUEENSLAND: Townsville (*Priestley*).

Aedes (Finlaya) australiensis (Theo.).

Leucomyia australiensis, Theobald, Mon. Cul. v, p. 313 (1910).

Distinguished especially by having the anterior half of the mesonotum clothed with creamy whitish scales. The still unique type is considerably damaged, but the species should be easily recognisable, as it appears to have no close ally in the Australasian fauna except *A. auridorsum*, Edw., and *A. papuensis* (Taylor).

Aedes (Finlaya) auridorsum, Edw.

Aedes (Finlaya) auridorsum, Edwards, Bull. Ent. Res. xii, p. 93 (1922).

Differs from *A. australiensis* chiefly in having the mesonotal scales bright golden, the first segment of the mid tarsi more extensively white, and the female palpi rather longer.

QUEENSLAND: Brigalow Scrub and Eidsvold (*Bancroft*).

The type was recorded as coming from Sydney, but Dr. Ferguson informs me that this was through an error of labelling; it was really collected by Dr. Bancroft at Eidsvold.

Aedes (Finlaya) papuensis (Taylor).

Leucomyia australiensis var. *papuensis*, Taylor, Trans. Ent. Soc. 1913, p. 193 (1914).

Although very close to *A. (F.) australiensis* (Theo.) this is certainly a distinct species, differing in having the scales on the sides of the head and mesonotum dark, the pale scales of the thorax and abdomen pure silvery white, pale bands of abdomen narrow and straight, not broadening out in the middle, etc.

PAPUA: Milne Bay (*Breinl*).

Aedes (Finlaya) biocellatus (Taylor).

Culex biocellatus, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 463 (1914).

Near *A. auridorsum*, Edw., but at once distinguished by having two yellow marks on the costa, one at the base of the wing and the other at the tip. The last two hind tarsal segments are missing in the type.

NEW SOUTH WALES: Milson I. (*Ferguson, Cleland*).

Aedes (Finlaya) albitarsis (Taylor).

Leucomyia ? *albitarsis*, Taylor, Trans. Ent. Soc. 1913, p. 194 (1914).

Described as having the "thorax brown, clothed with narrow curved brown hair-like scales and a median line of pure white ones extending from the anterior margin to the level of the roots of the wings"; prothoracic lobes with flat white scales;

abdominal segments 2-5 with basal white bands; first four hind tarsal segments with basal white rings. I have not seen the type, but there can be little doubt that it belongs to this subgenus.

PAPUA: Lakekamu (*Giblin*).

***Aedes (Finlaya) palmarum*, sp. n.**

Allied to *A. (F.) albitarsis* (Taylor), but differing from his description in the following particulars:—The median pale stripe of the thorax is moderately broad (it could hardly be described as a "line") and composed of golden, not white scales; prothoracic lobes (and also proepimera) with flat black scales; abdomen unbanded dorsally.

N. QUEENSLAND: Palm Island (*G. F. Hill*); type ♀ presented to the British Museum by the Imperial Bureau of Entomology in 1921.

The specimen was determined by Mr. Hill as *Leucomyia albitarsis*, Taylor, but in view of the difference mentioned above I hardly think it can be the same species. Hill, however, mentions variability in the colour of the pale scales of the scutum, some specimens having them white, as in the New Guinea type.

***Aedes (Finlaya) notoscriptus* (Skuse).**

Culex notoscriptus, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1738 (1889).

Stegomyia notoscriptus, Theobald, Mon. Cul. i, p. 286 (1901).

A common semi-domestic species, easily recognised by the conspicuous white lines on the thorax, femora and tibiae, and the ringed proboscis and tarsi. It is subject to a certain amount of variation. One specimen in the British Museum has the hind tarsal rings narrow, the last segment all black. Some (but not all) of the New Zealand specimens have the white scales of the thorax largely replaced by golden-yellow ones.

The larvae are said to breed in water-butts, but Skuse's statement that they "are hatched from boat-like masses of nearly three hundred eggs" probably rests on a confusion with *Culex fatigans*. Hill records rearing the species from tree-holes and fire-buckets.

Apparently common throughout Australia and Papua, occurring also as follows:

DUTCH E. INDIES: Saparoea (*Brug*). NEW CALEDONIA: Upper Houailou River (*P. D. Montague*). NEW ZEALAND: Grafton, Glenalvon, St. Mary's Bay (*Miller*).

***Aedes (Finlaya) pulcherrimus* (Taylor).**

Mimeteomyia pulcherrima, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 830 (1919).

Rather similar in most respects to *A. (F.) notoscriptus*, but there is some difference in the thoracic ornamentation, the white lines being composed of small broad instead of narrow scales, and the proboscis lacks the pale ring. Larvae in tree-holes.

QUEENSLAND: Cairns (*Taylor*); Townsville (*Hill*); Eidsvold? (*Bancroft*).

***Aedes (Finlaya) aureostriatus* (Dol.).**

Culex aureostriatus, Doleschall, Nat. Tijd. Ned. Ind. xiv, p. 385 (1857).

This was described from Amboina, the description and figure evidently indicating some species of *Finlaya*. The British Museum has a single female from Alor, near Timor (*S. L. Brug*), which may possibly be this species; it agrees tolerably well with the published data, except that the white lateral spots on the abdominal tergites are basal in position and not apical as indicated by Doleschall. I suspect that Doleschall

was mistaken, as most if not all the species of *Finlaya* known to me have the pale markings of the abdomen basal in position. Doleschall's figure apparently omits the posterior part of the mesonotum, probably owing to the way in which his specimen was pinned.

The specimen before me rather closely resembles the Ceylonese *A. (F.) greeni*, Theo., in almost every respect, differing only in having three separate golden lines on the anterior half of the mesonotum (the lines not suffused into a golden patch as in *A. greeni*, though less sharply defined than in *A. macdougalli*, Edw., or *A. quinquelineatus*, Edw.), and in the rather broader white rings of the hind tarsi, the fifth segment being all white above.

***Aedes (Finlaya) quinquelineatus*, Edw.**

Aedes (Finlaya) quinquelineatus, Edwards, Bull. Ent. Res. xiii, p. 93 (1922).

This is perhaps the Australian representative of *A. aureostriatus* (as identified above), from which it differs chiefly in the following particulars:—The lines on the mesonotum are more sharply defined; the scutellum has broad white scales instead of narrow brown and golden ones; the proboscis has a narrow but distinct pale ring in the middle, and the rings on the hind tarsi spread more extensively on to the apices of the segments. From *A. notoscriptus* an obvious distinction is in the absence of white lines on the tibiae.

QUEENSLAND: Eidsvold? (*Bancroft*).

***Aedes (Finlaya) lauriei* (Carter).**

Ochlerotatus lauriei, Carter, Proc. Zool. Soc. 1920, p. 623 (1920).

Somewhat resembles *A. quinquelineatus*, Edw., and *A. aureostriatus* (Dol.), but the middle thoracic stripe is rather broader, rather less sharply defined, and abbreviated posteriorly; the sublateral stripes are scarcely indicated except on the posterior half of the scutum. The proepimeral scales are mostly small, flat and dark.

The larvae have been described by Carter and were found in the hollow of a fallen tree.

LORD HOWE ISLAND (*Laurie*).

***Aedes (Finlaya) quasirubrihorax* (Theo.).**

Culex quasirubrihorax, Theobald, Mon. Cul. v, p. 348 (1918).

Nearly related to the following three species, but quite distinct and easily recognised by the white fifth segment of the hind tarsi, by the proepimeral scales being all narrow and pale without any flat black ones, and the brighter golden scales of the thorax, which are not spread over the whole surface but arranged in more or less definite lines. Between the lines of golden scales are a variable number of black ones, which in the northern specimens are much more numerous, thus rendering the golden lines more conspicuous. Perhaps these northern specimens may represent a distinct variety, but the difference mentioned is only one of degree, and the other characters seem to be fairly constant. The species affords a good connecting link between the *aureostriatus* group and the *alboannulatus* group.

QUEENSLAND: Eidsvold (*Bancroft*); Townsville and Palm Island (*Hill*).

Aëdes (Finlaya) alboannulatus (Macq.).

Culex alboannulatus, Macquart, Dipt. Exot. Supp. iv, p. 10 (1849).

This is one of three or four very nearly allied species which in general appearance rather closely resembles species of the subgenus *Ochlerotatus*, e.g., *O. labeculosus*; in regard to the genital structure, however, both sexes are quite typical of *Finlaya*. From most of the ringed-legged species of *Ochlerotatus* they may be distinguished at a glance by the broader and more conspicuous white ring on the first segment of the hind tarsi. In this and the following two species (which might indeed be regarded as merely varieties) the proepinera have a rather large patch of flat black scales posteriorly, and narrow golden ones above and in front.

A. alboannulatus differs from the next two in having a more or less obvious whitish ring before the tip of the femora (sometimes obsolete on the anterior legs), in the more pronounced speckling of pale scales on the tibiae, in the presence of a more or less distinct pale area in the middle of the proboscis on the underside, and in the largely white-scaled venter, with black median patches more or less as in *A. (O.) camptorhynchus*. The male hypopygium is practically identical in structure in all the three forms, but this is frequently the case in the subgenus *Finlaya* with species which are certainly quite distinct.

According to Bancroft the larvae of this species are found in freshwater lagoons and sometimes in wells; unusual habitats for a member of this subgenus.

QUEENSLAND: Burpengary and Eidsvold (*Bancroft*); Stanthorpe (*Wesche*). NEW SOUTH WALES: Mt. Victoria (*Bancroft*); Narromine and Milson I. (*Ferguson*); Locksley (*Cleland*); Sydney (*Thomson*); Woronora and Blue Mts. (*Skuse*). VICTORIA: Healesville (*Bancroft*); Melbourne (*French*); Beaconsfield (*Hill*).

Aëdes (Finlaya) queenslandis (Strickland).

Culex occidentalis, Theobald (*nec* Skuse), Mon. Cul. i, p. 419 (1901).

Culicelsa similis, Strickland, Entom. xlv, p. 132 (1911).

Culicelsa queenslandis, Strickland, *ibid.*, p. 179 (1911).

Culicada demansis, Strickland, *ibid.*, p. 202 (1911).

Culicada cumpstoni, Taylor, Trans. Ent. Soc. 1913, p. 692 (1914).

Culicada hybrida, Taylor, Proc. Linn. Soc. N.S.W. xli, p. 568 (1916).

This is very closely related to *A. alboannulatus*, but is certainly distinct on account of the absence of the pre-apical pale ring on the femora and of scattered pale scales on the tibiae, also by the uniformly dark-scaled proboscis and the different scaling of the venter. In this species the venter is mainly covered with pale yellowish scales, with an irregular sprinkling of dark scales; these dark scales are usually few in number, but occasionally, as in the type of *A. similis*, they are more numerous than the pale ones, especially towards the end of the abdomen. In some specimens, but not in all, there is a slight darkening of the wing-membrane across the middle; such specimens might be confused with *A. vandema*, but are easily distinguished by the structure of the abdomen as well as by the absence of lower mesepimeral bristles and of pale scales on the wing.

I have examined Strickland's types in the British Museum, and also a paratype of Taylor's *C. cumpstoni*; I have not seen the unique type of *C. hybrida*, but from the description I feel sure it is nothing but a variety of *A. queenslandis* with unbanded abdomen. The oldest name is *similis*, but this is preoccupied by *A. (Skusea) similis*, Theo.

Like the last, this species is said by Bancroft to breed in wells.

QUEENSLAND: Burpengary (*Bancroft*). NEW SOUTH WALES: Bulli (*Taylor*); Milson I. (*Ferguson*). VICTORIA: Healesville (*Bancroft*); Melbourne (*Cumpston*). TASMANIA: Hillwood and Lindisfarne (*Littler*); Westmoreland Falls (*C. L. Edwards*). S. AUSTRALIA: Mt. Lofty (*Cleland*).

Aedes (Finlaya) milsoni* (Taylor).

Culicada milsoni, Taylor, Proc. Linn. Soc. N.S.W. xl, p. 179 (1915).

Hulecoetomyia milsoni, Taylor, *ibid.*, xli, p. 566 (1916).

Closely allied to *A. queenslandis* (Strick.), differing chiefly in the much darker thorax (integument and scales), and in the scaling of the venter, which has a median longitudinal black stripe, and a transverse black band at the apex of each segment leaving only a pair of basal lateral patches of white (not yellowish) scales. According to Taylor, the male has "a thin and fairly long appendage, hairy at its apex, with its origin at the base of the fourth tarsus of the mid leg, extending to the apex of the fifth." There is no such structure in *A. queenslandis*, nor indeed in any mosquito known to me; it is not present in two males from Hawksburgh in the British Museum, which I believe to belong to this species. Probably, therefore, Taylor described some foreign body.

NEW SOUTH WALES: Milson I. and Hawksburgh (Ferguson). QUEENSLAND: Eidsvold (Bancroft), Stanthorpe (Wesche).

Subgenus ***Macleaya***, Theobald.

This name may perhaps be retained for a single Australian species which though apparently related to *Finlaya* shows several rather well-marked differences. The male hypopygium has well-developed claspettes, but they seem to be quite disconnected from the side-pieces, and the appendage is not distinctly jointed on to the stern; there is a dense hair-patch at the base of the side-piece on the inner side. The aedoeagus is undivided, as in *Finlaya* and *Ochlerotatus*. The female differs from either of these subgenera in having simple claws; the abdomen is depressed rather than compressed, and the eighth segment, though fairly large, is retracted and usually hardly visible externally.

***Aedes (Macleaya) tremula* (Theo.).**

Macleaya tremula, Theobald, Entom. xxxvi, p. 154 (1903).

Danielsia minuta, Taylor, Bull. Northern Terr. ia, p. 30 (1912).

Danielsia alboannulata, Taylor, *ibid.*, p. 31 (1912).

Aëdimorphus australis, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 457 (1914).

Aëdimorphus australis var. *darwini*, Taylor, *ibid.*, p. 458 (1914).

Mimeteomyia doddi, Taylor, *ibid.*, xliii, p. 831 (1919).

A small species of rather stumpy build, differing from almost all the other Australian species of the genus by the ornamentation of the hind tarsi, which have white rings at the bases of the first three segments, fourth segment all black, fifth all white. The species of the subgenus *Chaetocruiomyia* have the same tarsal ornamentation, but from these *A. (M.) tremula* differs in having no tuft of long scales at the base of the wing, as well as in the ornamentation of the thorax.

I have examined types or authentic specimens of all Taylor's species mentioned above, with the exception of *D. alboannulata*, the type of which has been destroyed, and give the synonymy without hesitation. The very slight differences which exist are evidently only individual variations. Larvae recorded by Bancroft from wells and casks, and by Hill from tree-holes, etc.

NORTHERN TERRITORY: Wandj and Darwin (Hill). QUEENSLAND: Deception Bay and Eidsvold (Bancroft); Palm Isl. and Townsville (Hill). PAPUA: Itikinumu (Dodd).

* Dr. Ferguson finds that Skuse's type of *C. occidentalis* is a *Finlaya*; it may perhaps be this species. See p. 376.

Subgenus **Pseudoskusea**, Theo.

This name may be retained for a small group of species that resemble *Ochlerotatus* in having long male palpi which are hairy and somewhat swollen at the tip, and also in the simple, smooth mesosome of the aedoeagus and the longish terminal spine of the claspers, but differ from both *Ochlerotatus* and *Finlaya* in the entire absence of claspettes.

In the typical species, *A. multiplex* (Theo.) and *A. bancroftianus* (Edw.), the head is clothed almost entirely with broad flat scales, the scutellum with narrow scales only; there are no lower mesepimeral bristles; the female has toothed claws, and a very small retractile eighth segment, with long cerci; the male has no apical and very indefinite basal lobes to the side-pieces of the hypopygium. Two other species, *A. culiciformis* (Theo.) and *A. cairnsensis* (Taylor), which are still only known in the female sex, are referred here provisionally; they appear to agree with the type in most respects, except that the claws are all simple. The proepimera are either quite bare (as in *multiplex*) or carry a few narrow pale scales.

A second small group of species may also be included here for want of a better place; this consists of three very closely allied species, *A. concolor* (Taylor), *A. crucians* (Walker) and *A. ashworthi* (Edw.). The generic name *Caenocephalus* was proposed by Taylor for this group, but had been used before by van der Wulp for a genus of STRATIOMYIDAE. I do not think it necessary to propose a substitute name, because the male hypopygium has practically the same structure as in *Pseudoskusea*, but there are some rather considerable differences from the species of the first group: the top of the head carries only narrow scales, and there are distinct lower mesepimeral bristles present, as in typical *Ochlerotatus*; the female has the eighth segment rather large and only partly retractile, with short cerci, much as in *Finlaya*. The basal lobes of the male side-pieces are much better developed than in the *multiplex* group, while in all three species the proepimera carry flat black scales only.

Aedes (Pseudoskusea) multiplex (Theo.).

Pseudoskusea multiplex, Theobald, Mon. Cul. iv, p. 192 (1907).

Quite distinct from its allies by the narrow transverse band of ochreous scales across the middle of the mesonotum. The proepimera are devoid of scales; the abdomen is unbanded, with the seventh segment in the female fairly large.

QUEENSLAND: Deception Bay (*Bancroft*). PAPUA: Friedrich-Wilhelmshafen (*Bird*) (recorded by Theobald, but probably a distinct species).

Aedes (Pseudoskusea) bancroftianus (Edw.).

Aedes (Ochlerotatus) bancroftianus, Edwards, Bull. Ent. Res. xii, p. 74 (1921).

Evidently allied to the above, but lacks the transverse pale band on the mesonotum, and has a very small seventh abdominal segment in the female.

Aedes (Pseudoskusea ?) culiciformis (Theo.).

Skusea culiciformis, Theobald, Ann. Mus. Nat. Hung. iii, p. 77 (1905).

The abdomen is banded, and except for the simple claws and the much larger seventh abdominal segment the species rather closely resembles *A. bancroftianus*, (Edw.)

PAPUA: Panmonur River (*Bird*). N. AUSTRALIA: Moa I. (*Hill*).

Aedes (Pseudoskusea) ?) cairnsensis, Taylor.

Pseudoskusea cairnsensis, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 829 (1919).

Differs from *A. culiciformis* (according to the description) chiefly in the unbanded abdomen. It is possible that this should be placed in *Aedes* s. str., and it may even be synonymous with *A. similis* (Theo.).

QUEENSLAND: Cairns (Taylor).

Aedes (Pseudoskusea) crucians (Walker).

Culex crucians, Walker, Ins. Saund., Dipt. i, p. 432 (1856).

Culicada tasmaniensis, Strickland, Entom. xiv, p. 181 (1911).

A rather large species. Male palpi with the last segment slender. Clasper very much swollen in the middle; side-piece with only a few flattened bristles on the inner margin towards the base.

TASMANIA: localities not stated (Walker, Bancroft).

Aedes (Pseudoskusea) concolor (Taylor).

Caenophthalmus concolor, Taylor, Trans. Ent. Soc. 1913, p. 1700 (1914).

Differs from *A. (P.) crucians* in its small size, much less swollen claspers, and swollen last segment of the male palpi. It should perhaps be regarded as only a variety of the above.

NEW SOUTH WALES: Cronulla (Mrs. Cleland). Larvae in salt water pools in rocks.

Aedes (Pseudoskusea) ashworthi (Edw.).

Ochlerotatus ashworthi, Edwards, Bull. Ent. Res. xii, p. 75 (1921).

Closely resembles *A. (P.) concolor*, differing only in the male hypopygium. The claspers are slender, not at all swollen, and the inner margin of the side-piece carries a row of flattened bristles.

WEST AUSTRALIA: Yallingup (Ashworth).

Subgenus **Aedes**, Mg., s. str.

The species now included in this genus all have short palpi in the male, mostly flat scales on the head, narrow scales on the scutellum, and no strong lower mesepimeral bristles. All are rather similar in external appearance, and few show any special ornamentation, all having dark tarsi. *A. cinereus*, the type species, has no lower mesepimeral hairs, and in the structure of its larva and aedeagus is evidently related to species of the subgenus *Aedimorphus*, such as *A. vexans*, Mg. Most of the Oriental species, however, have several, sometimes a large number, of fine short hairs towards the posterior margin of the lower part of the mesepimeron,* and these species have an aedeagus of a rather different structure. All but *A. bancrofti* of the species mentioned below belong to this Oriental group. If at any time it seems desirable to treat it as a separate subgenus, the name *Verrallina* is available for it. The structure of the female claws is evidently not of great importance here, as they may be simple or toothed in such evidently nearly related species as *A. funereus* and *A. similis*, and *A. panayensis* and *A. carmentis*.

* I am indebted to Dr. S. L. Brug for calling my attention to this character.

Aëdes (Aëdes) incertus, Edw.

Aioretomyia taeniata, Leicester, Cul. of Malaya, p. 190 (1908) (nom-preocc.).

Aëdes (Aëdes) incertus, Edwards, Ind. J. Med. Res. x, p. 468 (1922).

Differs from the following species in the reddish-tinged mesonotum and the conspicuous pearly-white basal bands on the abdominal tergites. The male is here recorded for the first time; it agrees well with the females in the British Museum from the Malay Peninsula and Borneo.

S. PAPUA: Merauke (*Dr. S. L. Brug*); 1 ♂ presented to the British Museum by the collector.

Aëdes (Aëdes) funereus (Theo.).

Skusea funerea, Theobald, Mon. Cul. iii, p. 292 (1903).

Pseudoskusea basalis, Taylor, Ann. Rept. Con. Pub. Health Queensland; App. 6, p. 27 (1912).

Skusea pseudomediofasciata, Taylor (*nec* Theo.), Proc. Linn. Soc. N.S.W. xliii, p. 838 (1919).

In this also the abdomen is distinctly banded, but the bands are narrower and distinctly removed from the bases of the segments (this is true of Taylor's *P. basalis*, an examination of the type proving it to have been wrongly described). The toni are dark in colour; the scales on the upper part of the sternopleura are partly dark and partly whitish; the female claws are simple; and the mesonotal scales are all dark brown.

NORTHERN TERRITORY: Darwin (*Hill*). QUEENSLAND: Palm Island (*Hill*); Cairns (*Taylor*); Deception Bay (*Bancroft*). AMBOINA (*Swellengrebel*). PAPUA: Mekeo (*Breinl*).

Aëdes (Aëdes) funereus var. ornatus (Theo.).

Skusea funerea var. *ornata*, Theobald, Ann. Mus. Nat. Hung. iii, p. 79 (1905).

Lepidotomyia lineata, Taylor, Trans. Ent. Soc. 1914, p. 191 (1914).

Differs from the typical form in the ornamentation of the mesonotum, which has fairly distinct median and lateral golden lines. The structural characters, including those of the hypopygium, are the same.

PAPUA: Sattelberg and Friedrich-Wilhelmshafen (*Biró*); Mekeo (*Breinl*); Namanula (*Heydon*). CERAM: Wekai (*Swellengrebel*). NEW BRITAIN: Rabaul (*Hill*).

Aëdes (Aëdes) similis (Theo.).

Pseudoskusea similis, Theobald, Mon. Cul. v, p. 189 (1910).

Appears to be closely related to the preceding, differing as follows:—Abdominal bands incomplete dorsally; toni ochraceous or light brownish; scales on upper part of sternopleura all white.

QUEENSLAND: Kuranda and Burpengary (*Bancroft*). AMBOINA: Saparoea l. (*Schreuder*).

Aëdes (Aëdes) carmentis, sp. n.

A deep black species closely resembling *A. funereus*, Theo., and *A. similis*, Theo. Tori blackish. Scales on upper part of sternopleura all dark. Abdominal bands incomplete dorsally. Front and middle claws of female toothed. The very similar *A. butleri*, Theo. (Oriental Region) differs in its rather smaller size, white upper sternopleural scales, and smaller lateral white spots on the abdomen.

SOLOMON Is.: Maravovo, Guadalcanar I., vi. 1923 (*Dr. A. G. Carmant*); numerous ♀♀ taken in bush and in native houses. N. QUEENSLAND: Palm Island (*G. F. Hill*); 1 ♀ in company with *A. funereus*.

***Aedes* (? *Aedes*) *bancrofti* (Taylor).**

Skusea bancrofti, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 465 (1914).

An obscure species of rather doubtful validity, apparently distinguished from the above four species by the pale mesonotal scales, and from all except *A. carmentis* by the toothed female claws. The palpi of the male described by Taylor are presumably short, otherwise the species must be very similar to *A. bancroftianus*. A female in the British Museum which may belong to this species has the abdomen more like that of *A. similis*, but it has no lower mesepimeral hairs. The name *bancrofti* should perhaps be regarded as preoccupied by *Culex bancrofti* Skuse, a synonym of *A. argenteus*, Poiret.

QUEENSLAND: Eidsvold (*Bancroft*).

Subgenus ***Leptosomatomyia***, Theo.

The single species of this subgenus is recorded from Papua; it is imperfectly known and of doubtful affinities.

***Aedes* (*Leptosomatomyia*) *lateralis*, Theo.**

*Leptosomatomyia lateral**is*, Theobald, Ann. Mus. Nat. Hung. iii, p. 110 (1905); Edwards, Bull. Ent. Res. xiii, p. 98 (1922).

The male type is still unique; it is distinguishable from members of the subgenera *Aedes* and *Skusea* by the more slender build and the hypopygial structure. The coloration is somewhat like that of *A. (Skusea) aurimargo*, Edw., and it is possible that the two may be synonymous. In view of this possibility I refrain from proposing a substitute for the name *lateralis*, which is preoccupied in *Aedes*.

PAPUA: Muina (*Biró*).

Subgenus ***Skusea***, Theo.

I have previously used this name to include all those species of *Aedes* with little or no ornamentation and simple female claws, which were excluded by male genital structure from the other more clearly defined subgenera. I would now restrict the group somewhat further, and include only those species which have broad flat scales on the scutellum. Two Australian species, *A. funereus* and *A. similis*, have only narrow scales on the scutellum and are, I think, better placed in the subgenus *Aedes*, in spite of the simple female claws. The remaining species still show considerable structural diversity, but seem to form a more or less natural group. Most of them possess distinct and fairly strong bristles on the anterior margin of the mesepimeron, thus differing from *Aedes* s. str. (and the related subgenus *Aedinorphus*), in which these bristles never occur. Some, however (such as *A. longirostris* Leic.), lack these bristles, while two described below (*A. fimbripes* and *A. tonsus*) have instead a row or small patch of fine short hairs near the posterior margin of the mesepimeron, just as in many species of *Aedes* s. str.

It is of interest to note that most of those species whose habits are known breed in crab-holes. Such are *A. pambaensis*, Theo., the type of the subgenus (as recently found by Dr. R. R. Scott), *A. cancricomus*, Edw., *A. longirostris* (Leic.), and *A. fimbripes*, sp. n. Exceptions are *A. micropterus* (Giles) and *A. reginae*, Edw., which breed in tree-holes.

***Aëdes (Skusea) aurimargo*, Edw.**

Aëdes (? *Skusea*) *aurimargo*, Edwards, Bull. Ent. Res. xiii, p. 94 (1922).

Differs from the next four species in the ornamented thorax, the mesonotum having a central line and a rather broad margin of golden scales. From *A. funereus* var. *ornatus*, which it somewhat resembles, it differs in the broad scutellar scales and in various details of coloration.

N. AUSTRALIA: Moa Island (*G. F. Hill*).

***Aëdes (Skusea) fimbripes*, sp. n.**

Head completely covered with flat scales, mostly black, but lighter round the eyes; upright scales and bristles black. Proboscis moderately slender, black-scaled, a little longer than the front femora. Palpi black-scaled, alike in the two sexes, about one-fourth as long as the proboscis, the two apparent segments equal in length, the second slightly thickened apically. Antennae of the male with rather scanty plumes; verticils in the middle of the segments, no short hairs at the tips; last two segments together almost equalling the rest of the flagellum in length. *Thorax* with dark brown integument; prothoracic lobes, scutellum, and pleural sutures lighter. Scutal scales all narrow, very dark brown. Proepimera and scutellum with a few dark brown flat scales. Small patches of light brown scales in the upper part of the sternopleura and mesepimera. About 5-6 proepimeral and 3-4 postspiracular bristles, all black. Mesepimera with light brown hairs; apart from the patch in the upper corner there is a continuous but irregular row along the posterior margin. *Abdomen* with dark brown scales, venter, and small basal lateral patches on the tergites lighter brown. Hypopygium: side-pieces elongate, somewhat distorted, over three times as long as their average width, with a large (apparent) ventral lobe in the middle which is densely clothed with long golden hair, apical part of lobe somewhat produced; part of side-piece distal to the lobe rather hairy, the rest with scales only. Clasper long, strap-shaped, with long slender terminal spine. Ninth tergite with two short bristles on each lobe. Aedoeagus small, lightly chitinated, constructed as in *Ochlerotatus*. *Legs* black-scaled, femora lighter beneath towards the base only. Front tarsus about one-fourth longer than the tibia, the first segment equalling the remaining segments in length. Larger claw on front legs of male toothed, on middle legs simple; female claws simple. First segment of hind tarsus scarcely shorter than the tibia. Hind tibia of male remarkably bristly: on the outer two-thirds of the inner (or posterior) surface a row of about 20 long fine hairs, and on the outer half of the externo-ventral surface an irregular row of about 12-15 more bristly hairs; also a fringe of shorter hairs on the dorsal surface. Hind tibiae of female normal, with only scattered bristles. *Wings* with dark scales, outstanding ones ligulate. Bases of fork-cells about level, upper fork about as long as its stem. Wing-length 2.8 mm.

NEW BRITAIN: Rabaul, in crab-holes (*G. F. Hill*). Type and paratype ♂ presented to the British Museum; paratypes ♂ ♀ in Mr. Hill's collection.

This species is very distinct from the other members of the subgenus, especially by the hind tibiae of the male. The hypopygium shows some resemblances, though not very close, to *A. (S.) amesi*, Ludlow.

***Aëdes (Skusea) tonsus*, sp. n.**

♂. Closely related to *A. (S.) fimbripes*, differing as follows:—Palpi rather more slender, not in the least swollen at the tip. Hind tibiae with only a few scattered bristles, no fringe. Side-pieces of hypopygium rather more slender and elongate, the median ventral lobe much less definite and without any hair-tuft.

AMBOINA: Saparoea, iii, 1922 (*Dr. S. L. Brug*); type ♂ presented to the British Museum by the collector.

Aedes (Skusea) longirostris (Leic.).

Ficalbia longirostris, Leicester, Cul. of Malaya, p. 228 (1908).

Uranotaenia hilli, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 841 (1919).

A very small obscure species; smaller than the two preceding and with relatively longer legs; the pleura are almost devoid of scales and there are no lower mesepimeral hairs. The male hypopygium is quite different in structure, and the palpi in both sexes are much shorter, being less than a tenth of the length of the proboscis.

NORTHERN TERRITORY: Darwin, in crab-holes (G. F. Hill).

Aedes (Skusea ?) daliensis (Taylor)

Stegomyia daliensis, Taylor, Proc. Linn. Soc. N.S.W. xli, p. 564 (1916).

I have not seen the type of this species, and only place it here provisionally. Since its describer referred this species to *Stegomyia*, it presumably has broad flat scales on the scutellum, otherwise it must be very similar to *A. (Pseudoskusea ?) culiciformis* (Theo.). It differs from the above three species in its banded abdomen.

NORTHERN TERRITORY: Daly River (Hill).

Genus **Lutzia**, Theo.

The single species occurring in the region has apparently spread from adjoining Malayan countries.

Lutzia halifaxi (Theo.).

Culex halifaxi, Theobald, Mon. Cul. iii, p. 231 (1903).

Lutzia halifaxi, Edwards, Ind. J. Med. Res. x, p. 274 (1922).

This large dark-coloured species has been recorded as *Culex tigripes* and *C. concolor*, but the Australian form differs slightly from these species and is nearly, if not quite, identical with the Malayan *L. halifaxi*. It is a common form in the northern part of Australia and in Papua, the most southerly record being Rydalmere, N.S.W. (Ferguson).

Genus **Culex**, L.

The not very numerous Australasian species of this genus may be distinguished by the following key:—

- | | |
|---|---------------------------------|
| 1. Proboscis and tarsi with distinct pale rings; lower mesepimeral bristle absent | 2 |
| Proboscis and tarsi uniformly dark, without pale rings (in <i>C. pacificus</i> the male only has an indistinct pale ring on the proboscis) | 10 |
| 2. Pale markings of abdomen mainly at the apices of the segments; wings with numerous pale scales... .. | <i>bitaeniorhynchus</i> , Giles |
| Pale markings of abdomen mainly at the bases of the segments | 3 |
| 3. Front two-thirds, or at least the middle third of scutum, clothed mainly with pale scales | 4 |
| Scutum dark-scaled or indistinctly mottled | 6 |
| 4. Tarsal rings narrow, and involving both ends of the segments | <i>squamosus</i> (Taylor) |
| Tarsal rings broader, at bases of segments only | 5 |

- | | | | |
|-----|--|--------|---------------------------------|
| 5. | Scales on front of scutum white | ... .. | <i>vicinus</i> (Taylor) |
| | Scales on front of scutum dull ochreous | ... .. | <i>basicinctus</i> , Edw. |
| 6. | Dark species, abdomen quite unbanded | ... .. | <i>samoensis</i> (Theo.) |
| | Abdomen distinctly banded | ... .. | 7 |
| 7. | Wings spotted | ... .. | <i>mimulus</i> , Edw. |
| | Wings unspotted | ... .. | 8 |
| 8. | Femora distinctly mottled with pale scales | ... .. | 9 |
| | Femora not mottled | ... .. | <i>crinicauda</i> , Edw. |
| 9. | Front tibiae with a row of pale dots in front; abdominal bands | ... .. |  |
| | more or less produced in the middle | ... .. | <i>annulirostris</i> , Skuse |
| | Front tibiae without row of pale dots; abdominal bands almost straight | ... .. | <i>sitiens</i> , Wied. |
| 10. | Pale markings of abdomen (bands or lateral spots) situated at the bases of the tergites; lower mesepimeral bristle present (except in <i>C. chaetovenralis</i>) | ... .. | 11 |
| | Pale markings of abdomen situated at the apices of the tergites, or else entirely absent | ... .. | 19 |
| 11. | Wing-scales moderately long and dense | ... .. | 12 |
| | Wing-scales very short and scanty (subgenus <i>Lophoceratomyia</i>) | ... .. | 16 |
| 12. | Pleura with small patches of scales (unless denuded) | ... .. | 13 |
| | Pleura devoid of scales (subgenus <i>Culicatomyia</i>)* | ... .. | 15 |
| 13. | Thoracic integument blackish brown; male clasper very broad | ... .. | <i>pacificus</i> , Edw. |
| | Thoracic integument lighter brown; male clasper more sickle-shaped | ... .. | 14 |
| 14. | Tenth sternites of male hypopygium with strong basal arm | ... .. | <i>pervigilans</i> , Berg. |
| | Tenth sternites of male hypopygium with the basal arm rudimentary or absent | ... .. | <i>fatigans</i> , Wied. |
| 15. | A conspicuous blackish spot at the base of the mesepimeron | ... .. | <i>pullus</i> (Theo.) |
| | This spot ill-defined and indistinct | ... .. | <i>muticus</i> , Edw. |
| 16. | Head with a rather broad margin of flat scales round the eye-margins | ... .. | 17 |
| | Head with the flat scales not extending all round the eye-margins | ... .. | 18 |
| 17. | Sixth antennal segment of male with a large scale-tuft | ... .. | <i>fraudatrix</i> (Theo.) |
| | Sixth antennal segment of male with a small scale-tuft | ... .. | <i>hilli</i> , Edw. |
| 18. | Scutal integument uniformly brownish | ... .. | <i>cylindricus</i> , Theo. |
| | Scutal integument greyish round the margin | ... .. | <i>chaetovenralis</i> (Theo.) |
| 19. | Head largely flat-scaled above; pleura without scales; lower mesepimeral bristle absent | ... .. | <i>cataractarum</i> , Edw. |
| | Head with at most a narrow rim of flat scales round the eye-margins | ... .. | 20 |
| 20. | Pleura without scales; lower mesepimeral bristle present | ... .. | <i>papuensis</i> (Taylor) |
| | Pleura with small patches of scales; lower mesepimeral bristle absent | ... .. | 21 |
| 21. | Abdominal tergites with apical lateral pale spots | ... .. | <i>fergusoni</i> (Taylor) |
| | Abdominal tergites uniformly dark-scaled | ... .. | <i>pseudomelanocoma</i> , Theo. |

Culex bitaeniorhynchus, Giles.

Culex bitaeniorhynchus, Giles, J. Bombay Nat. Hist. Soc. xiii, p. 607 (1901);
Edwards, Bull. Ent. Res. iv, p. 231 (1913).

Culicelsa abdominalis, Taylor, Rept. Austr. Inst. Trop. Med. 1911, p. 7 (1913).

Differs from *C. squamosus* in having rather more numerous pale scales on the wings, and conspicuous ochreous apical lateral spots or bands on the last few abdominal tergites, also in the hypopygial structure.

QUEENSLAND: Ayr, Townsville (Taylor, Hill). NORTHERN TERRITORY: Darwin (Hill). Also throughout the Oriental Region; has a strong tendency to the development of local races.

* This character applies also to the Oriental species of the subgenus, but not to the African.

***Culex squamosus* (Taylor).**

Trichopronomyia annulata, Theobald, Ann. Mus. Nat. Hung. iii, p. 98 (1905) (nom. preocc.).

Culicada squamosa, Taylor, Trans. Ent. Soc. 1913, p. 691 (1914).

Leucomyia annulirostris, Taylor, *ibid.*, p. 696 (1914).

Culex taylora, Edwards, Bull. Ent. Res. xii, p. 78 (1921)*.

The anterior two-thirds of the scutum are mainly covered with pale creamy scales; though there is a variable amount of darker scaling towards the front, there is generally a fairly sharp line of demarcation between the pale middle third and the darker posterior third. As in some allied species, there are a number of broad erect scales in the bristly area in front of the wing-roots. The pale tarsal rings involve both bases and apices of the segments. The femora and tibiae are conspicuously mottled with pale scales and there are also some scattered pale scales on the wings. The pale bands of the abdomen are scarcely if at all widened in the middle. The species is perhaps most nearly allied to *C. bitaeniorhynchus*, Theo., but there are few or no pale scales at the apices of the abdominal tergites, and the hypopygium differs considerably. I have not seen Theobald's type of *T. annulata*, but the description agrees with this species.

QUEENSLAND: Townsville (Priestley, Taylor, Hill); Ching Do (Taylor). PAPUA: Friedrich-Wilhelmshafen (Bird).

***Culex vicinus* (Taylor).**

Leucomyia annulata, Taylor, Trans. Ent. Soc. 1913, p. 695 (1914).

Leucomyia vicina, Taylor, Proc. Linn. Soc. N.S.W. xli, p. 569 (1916).

Quite distinct from the other Australian species with a banded proboscis in having the anterior half or more of the scutum clothed almost entirely with pure white scales, rarely with a slight creamy tint. The white rings of the hind tarsi are placed almost entirely at the bases of the segments; the femora and tibiae are not mottled. The species is nearly related to the Oriental *C. gelidus*, Theo., and *C. whitmorei* (Giles), differing from both in details of ornamentation and in hypopygial structure. I have compared the types and found them identical; the earlier name cannot be used as it has been employed on several occasions for other species which are now referred to *Culex*.

NORTHERN TERRITORY: Stapleton (Hill). QUEENSLAND: Townsville (Priestley).

***Culex basicinctus*, Edw.**

Culex basicinctus, Edwards, Bull. Ent. Res. xii, p. 78 (1921) and xiii, p. 96 (1922).

In many respects similar to *C. squamosus* (Taylor), and, like it, having the anterior two-thirds or at least the middle third of the scutum largely covered with pale scales, also with a similar patch of broad erect scales in front of the wing-roots. The clearest distinctions are to be found in the unusually short proboscis, which in the female is not more than four times as long as the palpi; in the markings of the abdomen, the white bands being more distinctly widened in the middle; and in the tarsal rings, which are broader than in *C. squamosus*, especially on the hind legs, and do not involve the apices of the segments. The femora are only slightly mottled, the tibiae not at all, and there are no pale scales on the wings.

QUEENSLAND: Townsville (Hill); Eidsvold (Bancroft).

Culex samoensis (Theo.).

Pseudotaeniorhynchus samoensis, Theobald, Entom. xlvii, p. 36 (1914).

An imperfectly known species, only two females having been collected. It is apparently quite distinct from the other ringed-legged species by the uniformly dark-scaled abdominal tergites. The scutum also is mainly dark, but shows traces of a pale transverse band behind the middle, indicating a probable relationship with the *bitaeniorhynchus*-group rather than with the *sitiens*-group.

SAMOA: Apia (Friederichs, O'Connor).

Culex mimulus, Edw.

Culex mimulus, Edwards, Bull. Ent. Res. v, p. 234 (March 1915).

Culex mossmani, Taylor, Proc. Linn. Soc. N.S.W. xi, p. 181 (June 1915).

Differs from all the other Australian species of the genus in its spotted wings. I have compared the hypopygia of *C. mimulus* and *C. mossmani* and find them identical. There is a difference in the wings, those of *C. mimulus* from the Oriental region generally having the third vein all dark, while *C. mossmani* shows a rather extensive pale-scaled area in the middle. This distinction, however, is inconstant.

QUEENSLAND: Mossman (Breinl and Priestley).

Culex sitiens, Wied.

Culex sitiens, Wiedemann, Aussereur. zweifl. Ins. i, p. 543 (1828).

Culex annulirostris, Theobald (*partim, nec* Skuse), Mon. Cul. i, p. 365 (1901).

?*Culex saibaii*, Taylor, Ann. Rept. Com. Pub. Health Queensland, p. 28 (1912).

Culicelsa paludis, Taylor, ♀, Austr. Inst. Trop. Med. Rept. 1911, p. 9 (1913).

Culicada annulata, Taylor, Trans. Ent. Soc. 1913, p. 669 (1914).

Culicelsa annulirostris var. *milni*, Taylor, Trans. Ent. Soc. 1914, p. 196 (1914).

Culex jepsoni, Theobald (type ♀), Entom. xliii, p. 158 (1910).

Culicelsa paludis, Taylor, ♂, Proc. Linn. Soc. N.S.W. xi, p. 181 (1915).

A small blackish species. Proboscis with a rather narrow pale ring, about a fifth as long as the whole proboscis. Mesonotum with a more or less mottled appearance owing to the mixing of light and dark brown scales. Pale bands of abdomen rather narrow, nearly pure white, with their posterior edges nearly straight. Sternites generally with distinct apical bands of black scales. Femora more or less distinctly mottled with pale scales in front; the front tibiae all dark in front except at the tip. Wings with the outstanding scales rather short and somewhat clavate; upper fork-cell with its base distinctly nearer the apex of the wing than that of the lower.

The larva apparently lives habitually in salt water; the species seems to be common on all coasts from Fiji and South Queensland to Somaliland. I have seen specimens from N. and S. Queensland, N. Territory, Fiji, Solomon Is., New Britain, Papua, Philippines, Celebes, Borneo, Java, Malay Peninsula, India, Ceylon, Aden and Somaliland.

Culex annulirostris, Skuse.

Culex annulirostris, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1737 (1889).

Culex jepsoni, Bahr, J. London Sch. Trop. Med. Supp. i, p. 18 (1912).

Culex palpalis, Taylor, Bull. Northern Terr. 1a, p. 29 (1912).

Culex somerseti, Taylor, Ann. Rept. Com. Pub. Health, p. 28 (1912).

Culicelsa consimilis, Taylor, Austr. Inst. Trop. Med. Rept. 1911, p. 8. (1913).

Culicelsa simplex, Taylor, Trans. Ent. Soc. 1913, p. 698 (1914).

Culex somerseti, Taylor, Proc. Linn. Soc. N.S.W. xli, p. 571 (1916).

Superficially very like *C. sitiens*, but quite distinct in many details of coloration as well as in the structure of the male hypopygium. Pale ring of proboscis broader,

fully a quarter of the whole length of the proboscis. Mesonotum more brownish than in *C. sitiens*, the scales rather variable but usually more uniform in colour. Pale bands of abdomen more or less distinctly produced in the middle, and more creamy white. Sternites without complete apical dark bands. Femora less distinctly mottled than in *C. sitiens*, but the front tibiae with rather numerous pale scales in front, which are aggregated into a row of small but fairly definite dots. Wings with the outstanding scales rather longer and narrower than in *C. sitiens*; bases of fork-cells level, or that of the upper slightly nearer the base of the wing than that of the lower.

I am indebted to Dr. E. W. Ferguson for examining Skuse's type of *C. annulirostris* and to Mr. G. F. Hill for the loan of Taylor's types. The species seems to be the commonest one of this group in Australia, and breeds partly if not entirely in fresh water. It does not occur outside the Australian region, unless *C. alis*, Theo. (from Christmas Island, S. of Java), is to be regarded as only a variety.

The male hypopygium differs from that of *C. sitiens* in the absence of the basal arm of the tenth sternites, and in other respects.

NEW SOUTH WALES: Blue Mts. (*Masters*); Berowra (*Skuse*). QUEENSLAND: Somerset, Innisfail, Cairns, Halifax (*Taylor*); Townsville (*Priestley, Taylor, Hill*), Ayr (*Taylor*); Eidsvold (*Bancroft*); Gympie (*Hill*). NORTHERN TERR.: Umbrawarra Creek (*Taylor*); Daly R. (*Hill*). DUTCH E. INDIES: Bangaii (*Brug*). FIJI: Suva, etc. (*Bahr*). SAMOA and ELLICE Is. (*O'Connor*). SOLOMON Is.: Guadalcanar I. (*Carment*).

***Culex crinicauda*, Edw.**

Culex crinicauda, Edwards, Bull. Ent. Res. xii, p. 77 (1921).

Culex parvus, Taylor (*nec* Macquart), Bull. Northern Terr. Ia, p. 27 (1912).

The smallest Australian species with a banded proboscis. Somewhat resembles *C. sitiens* and *C. annulirostris*, but the femora not mottled with pale scales, and the hypopygium of peculiar structure, the claspers broad with a tuft of hairs round their base. The Japanese *C. orientalis*, Edw., has a somewhat similar hypopygium, but has spotted wings.

NORTHERN TERRITORY: Umbrawarra Creek (*Taylor*).

***Culex fatigans*, Wied.**

Culex fatigans, Wiedemann, Aussereur. zweifl. Ins. i, p. 10 (1828).

Culex acer, Walker (*nec* Theo.), List Dipt. Brit. Mus. i, p. 7 (1848).

Culex macleayi, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1746 (1889).

Culex sp., Skuse, *ibid.*, p. 1748.

Culex skusii, Giles, Gnats, p. 292 (1900).

Culex pervigilans, Theobald (*partim, nec* Bergroth), Mon. Cul. iii, p. 206 (1903).

Culicella fuscus, Taylor, Trans. Ent. Soc. 1913, p. 699 (1914).

Culex townsvillensis, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 836 (1919).

This is the abundant domestic mosquito throughout the Australian region, occurring as far south as Launceston (*Littler*) and the North Island of New Zealand (Glenalvy, Erin Bay, Devonport, *D. Miller*). Its only close allies in the region are *C. pervigilans*, Bergr., which is confined to New Zealand, and *C. pacificus*, Edw., occurring only in the New Hebrides. The much denser wing-scales and the normal male antennae will distinguish it from the small species of the subgenus *Lophocera-tomyia*.

Culex pervigilans, Bergr.

Culex pervigilans, Bergroth, Wien. Ent. Zeits. viii, p. 295 (1889).

This is the antipodal representative of *C. pipiens*, L. It rather closely resembles that species and *C. fatigans*, but may usually be distinguished by the more conspicuous row of dark spots on the underside of the abdomen. These spots are always present in *C. pervigilans*, but though usually absent in the other two species they are to be found rather frequently in *C. pipiens* and occasionally in *C. fatigans* (e.g., in some specimens from Launceston). The only reliable distinction between the three forms seems to be in the hypopygial structure. In *C. pervigilans* this is nearly if not quite the same as in the East African *C. triflatus*, Edw.

C. pervigilans is an abundant and troublesome domestic mosquito throughout New Zealand. It is not yet certainly known from outside that country, the specimens recorded by Theobald from New South Wales being in reality *C. fatigans*. Some females collected by Mr. G. F. Hill at Melbourne may, however, belong to this species.

Culex (Lophoceratomyia) fraudatrix (Theo).

Lophoceratomyia fraudatrix, Theobald, Ann. Mus. Nat. Hung. iii, p. 93 (1905).

Lophoceratomyia cairnsensis, Taylor, Proc. Linn. Soc. N.S.W. xliii, p. 837 (1919).

? *Lophoceratomyia annulata*, Taylor, *ibid.*, xli, p. 571 (1916).

Distinguished from the other two Australian species of this subgenus by the large tuft of long scales on the sixth antennal segment of the male. In the typical form the abdomen is unbanded. Taylor's *L. annulata*, of which there is a paratype in the British Museum, does not differ from *C. fraudatrix* except for the inconspicuously banded abdomen. If it is not, as I suppose, a variety of this species, a new name will be required.

NEW SOUTH WALES: Stapleton (*Hill*). QUEENSLAND: Cairns and Halifax (*Taylor*); Townsville and Palm I. (*Hill*). NORTHERN TERRITORY: Daly River (*Hill*). PAPUA: Friedrich-Wilhelmshafen (*Bird*). NEW BRITAIN: Rabaul (*Hill*). Also known from Borneo and the Malay Peninsula.

Culex (Lophoceratomyia) hilli, Edw.

Culex (Lophoceratomyia) hilli, Edwards, Bull. Ent. Res. iii, p. 95 (1922).

? *Neomacleaya australis*, Taylor (*nec* Erichson), Proc. Linn. Soc. N.S.W. xl, p. 178 (1915).

The sixth antennal segment of the male carries a small and inconspicuous scale-tuft; the abdomen is unbanded. Taylor's *N. australis* may be either this species or *C. fraudatrix*.

NORTHERN TERRITORY: 70 miles S. from Darwin (*Hill*). N. QUEENSLAND: Halifax (*Taylor*).

Culex (Lophoceratomyia) cylindricus (Theo.).

Culex cylindricus, Theobald, Mon. Cul. iii, p. 202 (1903).

The thorax has a somewhat brighter reddish tint than in the last two species; the abdomen is conspicuously banded; and segments 6-8 of the male antennae are without scale-tufts, showing only the usual hair-whorls. The flat scales on the head are much less numerous than in the last two species, and do not extend quite round the eye-margins in front. The female rather closely resembles a small *C. fatigans*, but the male is easily recognised by the matted hair-pencil on the ninth antennal segment.

QUEENSLAND: Burpengary and Eidsvold (*Bancroft*); Palm I. (*Hill*).

Culex (Lophoceratomyia ?) chaetovenalis, Theo.

Neomelanoconion chaetovenalis, Theobald, Mon. Cul. v, p. 461 (1910).

The rather scantily scaled wings suggest that this species may belong to the subgenus *Lophoceratomyia*, but as it is still only known from the type female the reference is uncertain. It somewhat resembles *C. cylindricus*, Theo., and like that species has few or no flat scales on the top of the head, but it lacks the lower mesepimeral bristle; the margin of the scutum is distinctly greyish pruinose, the scutal scales are smaller and darker, and the pale bands on the abdomen, except that on the second segment, are interrupted in the middle.

QUEENSLAND: Kuranda (Bancroft).

Culex (Culiciomyia) muticus, Edw.

Culex (Culiciomyia) muticus, Edwards, Bull. Ent. Res. xiv., p. 6 (1923).

Differs from *C. papuensis*, Taylor, in the conspicuously banded abdomen, and also in the dark markings of the pleura, which are distinct but not very dark or sharply defined. As in the other species of the subgenus there is a narrow rim of small flat scales round the eye-margin, and a row of outstanding sharp-pointed scales on the long segment of the male palpi.

NEW BRITAIN: Rabaul (Hill). PAPUA: Merauke (Brug). AMBOINA (Brug).

Culex (Culiciomyia) pullus, Theo.

Culex pullus, Theobald, Ann. Mus. Nat. Hung. iii, p. 87 (1905).

This is quite possibly the same as the above, but after examining the type some years ago I noted that the pleural markings were the same as in the Oriental *Culiciomyia annulata*, Theo., i.e., with a nearly round, conspicuous blackish spot at the base of the mesepimeron. No fresh material is available, but as it is quite possible both species may occur in Papua the names may remain as they are for the present. The Oriental species differs from *C. muticus* in hypopygial characters, and in its lighter general colour.

PAPUA: Muina (Bird).

Culex (Culiciomyia) papuensis (Taylor).

Melanoconion papuensis, Taylor, Trans. Ent. Soc. 1914, p. 201 (1914).

I have examined the type of this species and find that it is a member of the subgenus *Culiciomyia*, very similar to the Oriental *C. fragilis*, Ludlow. As in all the Oriental species of this subgenus, there are no scales whatever on the pleura, and one fairly strong lower mesepimeral bristle is present. Some specimens from Amboina presented to the British Museum by Dr. S. L. Brug seem to be referable to this species; I have examined the male hypopygium and find that though in most respects similar to that of *C. fragilis* it differs conspicuously in the absence of the basal arm of the tenth sternites. The scales at the tip of the wing are also rather broader than in *C. fragilis*.

PAPUA: Lakekamu (Giblin). AMBOINA (Brug).

Culex (Neoculex) pseudomelanoconia, Theo.

Culex pseudomelanoconia, Theobald, Mon. Cul. iv, p. 416 (1907).

Distinguished from all the other Australian species with dark tarsi, by having the abdomen entirely clothed with dark scales above and below. There are no distinct knee-spots at the apices of the femora and tibiae, and no lower mesepimeral bristle.

The hypopygium of the male shows that the species is very closely related to the Holarctic *C. apicalis*, Adams, which is the type of Dyar's subgenus *Neoculex*.* It shows the following characters: Side-piece with the lobe slightly divided, the basal division with two long somewhat sinuous rods, the apical division with five stiff but hardly modified bristles; no leaf. Tenth sternites with a regular apical comb of about a dozen rather long blunt spines; no basal arm. Mesosome of aedeagus almost membranous, with only slightly developed processes.

S. QUEENSLAND: Burpengary (*Bancroft*).

***Culex (Neoculex ?) fergusonii* (Taylor).**

Culicada fergusonii, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 459 (1914).

This species is a true *Culex*, but I am uncertain of the subgenus, having examined only the female type. It is the only Australian *Culex* in which the pale markings of the abdomen are situated entirely at the apices of the segments. There is no lower mesepimeral bristle; the pronotal and proepimeral scales are all narrow; the hind femora and tibiae have distinct pale apical spots. The species is probably nearly related to *C. pseudomelanoconia*.

NEW SOUTH WALES: Milson I. (*Ferguson*).

***Culex cataractarum*, Edw.**

Culex cataractarum, Edwards, Bull. Ent. Res. xiv, p. 7 (1923).

One of the smallest species of the genus; obscure in coloration, but differing from all other species yet recorded from Australia or New Guinea in the very short palpi of the male. Other species with short male palpi will doubtless be discovered in the region; one of the Oriental forms (*C. malayi*, Leic.), has in fact been found in Timor (*Brug*), though not as yet farther east; it differs from *C. cataractarum* in the forked male claspers and in other respects.

NEW BRITAIN: Rabaul (*Hill*).

The following two species probably belong to the genus *Culex*, but as I have not seen the types I have not ventured to place them.

***Melanoconion ornatus*, Theo.**

Melanoconion ornatus, Theobald, Ann. Mus. Nat. Hung. iii, p. 100 (1905).

A small dark-legged species, easily distinguished (according to the description) by the pale golden scales at the sides of the chestnut-brown mesonotum. The figure of the wing suggests a species of the subgenus *Lophoceratomyia*.

PAPUA: Friedrich-Wilhelmshafen (*Biró*).

***Melanoconion pallidiceps*, Theo.**

Melanoconion pallidiceps, Theobald, Ann. Mus. Nat. Hung. iii, p. 101 (1905).

Another dark-legged species; the palpi of the male longer than the proboscis; said to be distinguished by the markings on the mesonotal integument; two dark lines in front and a pair of dark patches behind.

PAPUA: Friedrich-Wilhelmshafen (*Biró*).

* In Dyar's key to the subgenera of *Culex* (*Insector Inscitiae*, vi, p. 92, 1918), *Neoculex* is wrongly included in the group which has the tenth sternites tufted. Actually in the type species they terminate in quite a definite comb, much as in the present species, though the teeth are shorter.

INDEX.

(Synonyms in italics.)

<i>abdominalis</i> , Taylor	...	...	392	<i>australis</i> , Theo.	...	...	379
<i>acer</i> , Theo.	...	...	366	<i>bancrofti</i> , Giles	...	...	353
<i>acer</i> , Walk.	...	...	395	<i>bancrofti</i> , Skuse	...	...	370
<i>aconitus</i> , Dön.	...	...	351	<i>bancrofti</i> , Taylor	...	...	389
<i>aculeatus</i> , Theo.	...	...	373	<i>bancroftianus</i> , Edw.	...	...	386
<i>africanus</i> , Theo.	...	...	365	<i>barbirostris</i> , v.d. W.	...	351, 353	
<i>aitkeni</i> , Theo.	...	...	352	<i>basalis</i> , Tayl.	...	...	388
<i>albescens</i> , Tayl.	...	...	357	<i>basicinctus</i> , Edw.	...	...	393
<i>albirostris</i> , Macq.	...	...	376	<i>bimaculipes</i> , Theo.	...	...	360
<i>albirostris</i> , Theo.	...	...	375	<i>biocellatus</i> , Tayl.	...	...	381
<i>albitarsis</i> , Tayl.	...	...	381	<i>bitaeniorhynchus</i> , Giles	...	...	392
<i>alboannulata</i> , Tayl.	...	...	385	<i>breinli</i> , Tayl.	...	...	368
<i>alboannulatus</i> , Macq.	...	...	384	<i>brevicellulus</i> , Theo.	...	...	365
<i>albofasciata</i> , Tayl.	...	...	357	<i>brugi</i> , sp. n.	...	...	371
<i>albopictus</i> , Skuse.	...	...	370	<i>burpengaryensis</i> , Theo.	...	...	379
<i>alboscuteclatus</i> , Theo.	...	...	372	<i>butleri</i> , Theo.	...	...	351
<i>alternans</i> , Westw.	...	...	367	<i>cairnsensis</i> , Tayl. (Hod.)	...	...	359
<i>amboinensis</i> , Dol.	...	...	351	<i>cairnsensis</i> , Tayl. (Loph.)	...	...	396
<i>amictus</i> , Edw.	...	...	354	<i>cairnsensis</i> , Tayl. (Pseudosk.)	...	...	387
<i>annandalei</i> , Theo.	...	...	351	<i>cairnsensis</i> , Tayl. (Uran.)	...	...	357
<i>annulata</i> , Tayl. (Culic.)	...	...	394	<i>caledonica</i> , Edw.	...	...	361
<i>annulata</i> , Tayl. (Leuc.)	...	...	393	<i>camptorhynchus</i> , Thoms.	...	...	374
<i>annulata</i> , Tayl. (Loph.)	...	...	396	<i>cancer</i> , Leic.	...	...	357
<i>annulata</i> , Theo. (Trich.)	...	...	393	<i>carmenti</i> , sp. n.	...	...	388
<i>annulata</i> , Theo. (Culic.)	...	...	394	<i>castrensis</i> , Edw.	...	...	351
<i>annulipes</i> , Tayl.	...	...	374	<i>cataractarum</i> , Edw.	...	...	398
<i>annulipes</i> , Walk. (Anoph.)	...	...	354	<i>catasticta</i> , Knab.	...	...	364
<i>annulipes</i> , Walk. (Mans.)	...	...	365	<i>cephasi</i> , Edw.	...	...	362
<i>annulirostris</i> , Skuse	...	...	394	<i>chaetovenralis</i> , Theo.	...	...	397
<i>annulirostris</i> , Tayl.	...	...	394	<i>clelandi</i> , Tayl.	...	...	379
<i>annulirostris</i> , Theo.	...	...	394	<i>commovens</i> , Walk.	...	...	367
<i>antennalis</i> , Tayl.	...	...	358	<i>concolor</i> , Tayl.	...	...	387
<i>antipodeus</i> , Edw.	...	...	376	<i>conopas</i> , Theo.	...	...	365
<i>apicotriangulata</i> , Theo.	...	...	362	<i>consimilis</i> , Tayl.	...	...	394
<i>argenteiventris</i> , Theo.	...	...	361	<i>corethroides</i> , Theo.	...	...	352
<i>argenteus</i> , Poir.	...	...	370	<i>crinicauda</i> , Edw.	...	...	395
<i>argyropus</i> , Walk.	...	...	360	<i>crucians</i> , Walk.	...	...	387
<i>ashworthi</i> , Edw.	...	...	387	<i>culiciformis</i> , Theo.	...	...	386
<i>atra</i> , Tayl.	...	...	362	<i>cumpstoni</i> , Tayl.	...	...	384
<i>atra</i> , Theo.	...	...	357	<i>cunabulanus</i> , sp. n.	...	...	378
<i>atratipes</i> , Skuse	...	...	353	<i>cylindricus</i> , Theo.	...	...	396
<i>atripes</i> , Skuse	...	...	362	<i>daliensis</i> , Tayl.	...	...	391
<i>aureostriatus</i> , Dol.	...	...	382	<i>darwini</i> , Tayl.	...	...	385
<i>auredorsum</i> , Edw.	...	...	381	<i>demansis</i> , Str.	...	...	384
<i>auremargo</i> , Edw.	...	...	390	<i>doddi</i> , Tayl.	...	...	385
<i>australiensis</i> , Giles	...	...	365	<i>elegans</i> , Tayl.	...	...	364
<i>australiensis</i> , Theo.	...	...	381	<i>farauti</i> , Lav.	...	...	354
<i>australis</i> , Er.	...	...	377, 379	<i>fasciata</i> , Fab.	...	...	370
<i>australis</i> , Str.	...	...	377	<i>fatigans</i> , Wied.	...	...	395
<i>australis</i> , Tayl. (Aedim.)	...	...	385	<i>fergusoni</i> , Tayl.	...	...	398
<i>australis</i> , Tayl. (Neom.)	...	...	396	<i>filipes</i> , Walk.	...	...	362

<i>fimbripes</i> , sp. n.	390	<i>milni</i> , Tayl.... ..	394
<i>flavifrons</i> , Skuse	374	<i>milsoni</i> , Tayl. (Culic.)	385
<i>flavifrons</i> , Theo.	375	<i>milsoni</i> , Tayl. (Hulec.)	385
<i>findersi</i> , Tayl.	377	<i>mimulus</i> , Edw.	394
<i>fraudatrix</i> , Theo.	396	<i>minus</i> , Theo.	351
<i>frenchi</i> , Theo.	363	<i>minuta</i> , Tayl.	385
<i>frenchi</i> , Str.	378	<i>moluccensis</i> , Sw.	354
<i>fuliginosus</i> , Giles	351	<i>mossmanni</i> , Tayl.	394
<i>funereus</i> , Theo.	388	<i>multiplex</i> , Theo.	386
<i>fuscana</i> , Wied.	351	<i>musivus</i> , Skuse	354
<i>fuscocephalus</i> , Theo.	351	<i>muticus</i> , Edw.	397
<i>fuscus</i> , Hutton	367	<i>niger</i> , Theo.... ..	372
<i>fuscus</i> , Taylor	395	<i>nigerrima</i> , Tayl.	358
<i>giblini</i> , Tayl.	365	<i>nigra</i> , Tayl.	374
<i>gracilis</i> , Theo.	355	<i>nigrithorax</i> , Macq.	377
<i>halifaxi</i> , Theo.	391	<i>nivipes</i> , Theo.	357
<i>hilli</i> , Edw.	396	<i>nocturnus</i> , Theo.	372
<i>hilli</i> , Tayl. (Steg.)	362	<i>normanensis</i> , Tayl.	375
<i>hilli</i> , Tayl. (Uran.)	391	<i>notoscriptus</i> , Skuse	382
<i>hispidosus</i> , Skuse	367	<i>obturbans</i> , Walk.	368
<i>humeralis</i> , Edw.	370	<i>occidentalis</i> , Skuse	376, 385
<i>hybrida</i> , Tayl.	384	<i>occidentalis</i> , Theo.	384
<i>hyrcanus</i> , Pall.	351	<i>ornata</i> , Tayl.	361
<i>immisericors</i> , Walk.	356	<i>ornatus</i> , Theo. (Aëd.)	388
<i>imprimens</i> , Walk.	377	<i>ornatus</i> , Theo. (Melan.)	398
<i>incertus</i> , Edw.	388	<i>pallidiceps</i> , Theo.	398
<i>inornata</i> , Str.	374	<i>pallidus</i> , Sw.	351
<i>inornatus</i> , Walk.	356	<i>palmarum</i> , sp. n.	382
<i>insulae-florum</i> , Sw.	351	<i>palpalis</i> , Tayl.	394
<i>iracundus</i> , Walk.	366	<i>paludis</i> , Tayl.	394
<i>jepsoni</i> , Bahr.	394	<i>pampangensis</i> , Ludl.	372
<i>jepsoni</i> , Theo.	394	<i>papua</i> , Brug.	358
<i>kernorganti</i> , Lav.	367	<i>papnae</i> , Sw.... ..	352
<i>kochi</i> , Dön.	380	<i>papuensis</i> , Tayl. (Leuc.)	381
<i>kochi</i> , Theo.	351	<i>papuensis</i> , Tayl. (Melan.)	397
<i>labeculosus</i> , Coq.	374	<i>papuensis</i> , Tayl. (Taen.)	364
<i>lacuum</i> , Edw.	368	<i>parvus</i> , Tayl.	395
<i>lateralis</i> , Theo.	389	<i>pecuniosus</i> , Edw.	380
<i>lauriei</i> , Cart.	383	<i>pervigilans</i> , Bergr.	396
<i>leucosphyrus</i> , Dön.	351	<i>poicilia</i> , Theo.	380
<i>lewaldi</i> , Ludl.	351	<i>priestleyi</i> , Tayl.	381
<i>linealis</i> , Skuse	366	<i>procax</i> , Skuse	375
<i>linealis</i> , Tayl.	371	<i>procax</i> , Theo.	375
<i>lineata</i> , Tayl.	388	<i>propria</i> , Tayl.	357
<i>lineatopennis</i> , Ludl.	371	<i>pseudobarbitrostris</i> , Ludl.	353
<i>littleri</i> , Tayl.	363	<i>pseudomediofasciata</i> , Tayl.	388
<i>longirostris</i> , Leic.	391	<i>pseudomelanoconia</i> , Theo.	397
<i>ludlowi</i> , Theo.	351	<i>pseudoscutellaris</i> , Theo.	370
<i>luteolateralis</i> , Theo.	371	<i>pseudovigilax</i> , Theo.	375
<i>macleani</i> , Skuse	395	<i>pulcherrimus</i> , Tayl.	382
<i>maculatus</i> , Theo.	351	<i>pullus</i> , Theo.	397
<i>magnesiiana</i> , sp. n.	361	<i>punctolateralis</i> , Theo.	362
<i>malayi</i> , Leic.	351	<i>punctulatus</i> , Dön.	351, 354
<i>marinus</i> , Theo.	375	<i>purpurata</i> , Edw.	361
<i>mastersi</i> , Skuse	354	<i>purpureus</i> , Theo.	381

<i>pygmaea</i> , Theo.	357	<i>laeniata</i> , Leic.	388
<i>quasiornata</i> , Tayl.	361	<i>tasmaniensis</i> , Str. (Aëd.)	387
<i>quasirubrithorax</i> , Theo.	383	<i>tasmaniensis</i> , Str. (Culic.)	377
<i>quasisanguinae</i> , Leic.	358	<i>tasmaniensis</i> , Str. (Steg.)	362
<i>queenslandis</i> , Str.	374, 384	<i>tasmaniensis</i> , Tayl.	377
<i>quinquelineatus</i> , Edw.	383	<i>taylori</i> , Edw.	393
<i>rubrithorax</i> , Macq.	375	<i>tenuipalpis</i> , sp. n.	366
<i>sabaii</i> , Tayl.	394	<i>tesselatus</i> , Theo.	351
<i>sagax</i> , Skuse	378	<i>theobaldi</i> , Tayl.	375
<i>samoana</i> , Grünb.	380	<i>tibialis</i> , Tayl.	357
<i>samoensis</i> , Theo.	394	<i>tonsus</i> , sp. n.	390
<i>scutellaris</i> , Theo.	370	<i>townsvillensis</i> , Tayl.	395
<i>scutellaris</i> , Walk.	370	<i>tremula</i> , Theo.	385
<i>septemguttata</i> , Theo.	365	<i>triangulatus</i> , Tayl.	358
<i>septempunctata</i> , Theo.	365	<i>umbrosus</i> , Brug.	351
<i>similis</i> , Str.	384	<i>uniformis</i> , Str.	375
<i>similis</i> , Theo.	388	<i>uniformis</i> , Theo.	365
<i>simplex</i> , Tayl.	394	<i>vagus</i> , Dön....	351
<i>sinensis</i> , Theo.	351	<i>vandema</i> , Str.	374
<i>sitiens</i> , Wied.	394	<i>variegatans</i> , Str.	374
<i>skusii</i> , Giles	395	<i>variegatus</i> , Dol.	370
<i>solomonis</i> , sp. n.	363	<i>venustipes</i> , Skuse	364
<i>somerseti</i> , Tayl.	394	<i>vexans</i> , Mg....	372
<i>speciosus</i> , Skuse	356	<i>vicinus</i> , Tayl.	393
<i>spinosipes</i> , Edw.	370	<i>victoriensis</i> , Tayl.	374
<i>spoliata</i> , Edw.	359	<i>vigilax</i> , Edw.	372
<i>squamosus</i> , Tayl.	393	<i>vigilax</i> , Skuse	375
<i>stigmaticus</i> , Skuse	352, 355	<i>vittiger</i> , Skuse	373
<i>stricklandi</i> , Edw.	377	<i>westralis</i> , Str.	374
<i>subpictus</i> , Grassi	351	<i>wilsoni</i> , Tayl.	378
<i>subulifer</i> , Dol.	356	<i>xanthogaster</i> , nom. n.	366
<i>sylvestris</i> , Theo. (Rach.)	362	<i>zonatipes</i> , Walk.	370
<i>sylvestris</i> , Theo. (Chaet.)	370		

NOTES ON THE HIBERNATION OF ANOPHELES MOSQUITOS IN PALESTINE.

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During the months of January to April, 1923, a study was undertaken of the hibernation of Anopheline mosquitos in Palestine. Previous experience indicated that the activity of these mosquitos was greatly reduced during the winter months. It remained, however, to determine whether this inactivity was relative or absolute, that is, whether it was due to real hibernation or only to either retarded development of the immature stages or inhibited activity of the adults. Such information is, of course, of first importance in any attempt at intelligent control of malaria.

The problem was approached from different angles. The malaria sub-inspectors of the various control areas were instructed to conduct periodic searches for the immature stages, as well as systematic smokings for adult Anopheline mosquitos, and to report the stages, the numbers and species found. These reports were checked from time to time by personal inspections in different places. At the same time observations were made in the laboratory on the activity of mature and immature stages of Anophelines and the length of time required for their development at the temperature prevailing during the winter months.

Although these studies will have to be confirmed and extended next year, a considerable amount of information has been obtained, which we believe of sufficient general interest to be reported at this stage.

Field Observations.

Careful and repeated search made in the various control areas in different parts of Palestine for Anopheline larvae and pupae failed to reveal any breeding in the winter months. In January no *Anopheles* larvae were found anywhere except on the banks of the Kineret near Migdal. In this area they were found underneath the gravel up to 15th January, when the second series of heavy rains began. The midday temperature of the water at this point was 17°C. while in various other sections of the country it ranged between 12–15°C. During February and the greater part of March, no larvae or pupae were found anywhere. At the end of March (25th–31st) *Anopheles* larvae were found in the swamp in the eucalyptus grove in Kineret, in the wadi Solim near Merchavia, in the Athlit swamp and in the wadi Khudeira. The day temperatures at that time were 20°C. or over (in Kineret it rose to 25°C.), and the mean temperatures ranged between 18°C. and 22°C. The majority of these larvae proved to be *A. algeriensis*, but a few of them were *A. elutus*.

It is apparent that the immature stages of *Anopheles* mosquitos are practically absent (or present in such small numbers as to avoid detection) in all sections of Palestine during the months of January, February and March.* During the last days in March and early in April they reappear in various parts of the country, in localities as far apart from one another as Kineret in Galilee, Merchavia in the Valley of Esdraelon, Athlit in Phoenicia and Hedera in Samaria.

* This does not apply to the semi-tropical region of Jericho, since no observations were made there. As to breeding of *A. bifurcatus* in deep wells in the orange-growing area near Jaffa, in January and February, cf. E. E. Austen, Trans. Soc. Trop. Med. & Hyg., xii, no. 4, p. 51 (1919).

Field observations on adult mosquitos were concentrated chiefly on noting the species, numbers, favourite wintering places and relative activity. At the very beginning it was found that searching alone would not suffice, since it only enabled one to detect and catch a small percentage of the mosquitos. Other methods were therefore tested, and smoking, first used by Sella in Fumicino, was adopted as the most satisfactory. We devised a simple method, the underlying principle of which consists in driving the mosquitos from their hiding places to a single area of light, where they can easily be caught or killed. The details of the method have been described before;* here only a brief sketch will suffice. The stable or room is darkened completely except for the entrance. Over the entrance a white sheet is tacked. The smoke can be created in a number of ways, but the simplest is to light two or three piles of straw in different parts of the room, and as soon as the fire is well started, water or damp manure is thrown on it. In a minute or so the room is filled with a heavy smoke, and in a few minutes more all the insect life flocks to the sheet, and there the mosquitos can be easily caught.

The main results of these smokings are summarised in the table given below, from which it is clear that malaria-carrying *Anopheles* are found in considerable numbers in the different sections of Palestine during the winter months. That these mosquitos remained from the breeding season is evident from the fact that no active breeding was noted in any of these places that would account for such large numbers of imagines. These mosquitos do not, however, hibernate in the true sense of the word. The great majority of them, as may be seen from the table, seek the warmer store-houses in preference to sleeping and living rooms, but a large number of those captured showed evidence of a recent blood feed; and on warm days we repeatedly noted mosquitos trying to get into houses. Laboratory observations, which will be given below, also indicate that adult *Anopheles* show activity during the winter period.

Although the chief object of this work was to determine whether and to what extent the imagines of the malaria-transmitting *Anopheles* of Palestine remain inactive during the winter period, the smoking yielded other interesting information. It gave a very good idea of the extent and type of breeding in the various districts. In some places (Hedera, Merchavia, Mishmar and Yessod) only *A. elutus* was found, in other places (Yemma and Ecron) only the *superpictus-sergenti* group, and in still others, both species were equally present. In Hartuf only *A. bifurcatus* occurred. These data also give some indication of the chief source of breeding. Previous observations have shown that *A. elutus* breeds chiefly in stagnant bodies of water, clear or overgrown with vegetation, while *sergenti* and *superpictus* prefer the clear water of slow-moving streams or seepage pools under stones in wadi beds or on the shore of Lake Tiberias. Applying this information, we obtain a clue as to the chief breeding places from the species of mosquitos found.

The number of mosquitos also served as a check on the effectiveness of the control work. There was a definite correlation between the numbers of mosquitos and autumn epidemics of malaria. In those places in Galilee and the Valley of Esdraelon where there were epidemics in the autumn of 1922, the number of wintering mosquitos was high, and conversely, in those places where malaria was well under control the number of *Anopheles* was low.

Laboratory Observations.

Because of the late date, the material available for this study was limited. Nevertheless, the observations made in the laboratory throw light on the question of the hibernation of *Anopheles* in Palestine.

* J. M. Shapiro, "Smoking as a Method of Mosquito Control"—in the press.

Experiment 1.—On 3rd January, larvae of *A. bifurcatus* were found in the cisterns of Haifa and brought to the laboratory; they were in different stages of development, but the exact age was uncertain. The larvae were placed in shallow dishes at room temperature, and the temperatures outside and in the water were taken daily in the early morning and late afternoon. The maximum temperature during the period of observation was 17°C., the minimum 12°C., the mean 14.8°C. On 26th February the first pupa appeared, and on 3rd March, a female *A. bifurcatus* emerged. The mean temperature for the period between 26th February and 3rd March was 17°C. A second larva pupated on 1st April, and on 5th April the imago emerged. The rest of the larvae died.

It appears, therefore, that at the temperature prevailing in the open during the winter months, *A. bifurcatus* requires from two to three months for its development. This does not apply to cisterns, since the temperature of the Haifa cisterns, taken at intervals, ranged between 18°C. and 20°C. At this temperature, particularly, because it is quite constant and never reaches the low levels of water exposed to and affected by the fluctuations between day and night temperatures, the rate of development is undoubtedly much more rapid. However, under the conditions recorded, *A. bifurcatus* passed at least two to three months in the larval stage and five days in the pupal stage, or five to ten times the average period of its development at summer temperatures.

Experiment 2.—(A). Adult *A. clutus* caught at Athlit 10.i.23, after a recent blood feed and brought to the laboratory. On 15.i.23, fed on rabbit. On 19.i.23, deposited 158 eggs. Eggs not fertilised. Mean temperature of room, 10.i.23 to 19.i.23, 14.7°C.; minimum and maximum water temperature on 19.i.23, 13.7°C., and 14.5°C. respectively. The air temperature was always about one degree higher than that of the water.

(B). On 22.ii.23, another *A. clutus* was brought to the laboratory, apparently after a blood feed, deposited eggs, which hatched on 29.ii.23. Mean temperature 16.4°C., minimum temperature on 29.ii.23, 15.7°C. The larvae died after two weeks, but the change during that time was very slow.

These experiments show that *A. clutus* feeds and lays eggs at the prevailing winter temperature, but the development proceeds very slowly. It has been noted repeatedly that when the temperature falls below 12°C., the larvae remain inactive at the bottom of the dish, but resume activity as soon as the water is warmed up to 15°C. Judging from the length of time before the eggs hatched and the appearance of the larvae when they died, it can be said with certainty that full development at a mean temperature of 15°C. will take two months or longer. In other words, the larvae of *A. clutus*, as well as those of *A. bifurcatus*, can last the entire winter period, at the prevailing winter temperature in Palestine.

Experiment 3.—On 14th and 16th February algae were brought from Migdal and Yavniel to the laboratory, having been taken from typical breeding places. On 9th March three larvae emerged—one from material taken from Yavniel, two from that brought from Migdal; water temperature 17°C. On 29th March the Yavniel larva pupated, and on 3rd April a female *superpictus* emerged. On 5th April two male *superpictus* emerged from the Migdal larvae. These observations are important, because they indicate that eggs of *A. superpictus* can remain for some time (in this case one month) before they hatch, and that at a mean temperature of 17°C. *superpictus* requires about seven weeks for its development.

Summary.

The observations recorded in this paper reveal a number of interesting facts regarding the hibernation of mosquitos in Palestine. The various stages of the common malaria-transmitting species are able to survive part or all of the winter

months. Eggs of *A. superpictus* were in the laboratory 3½ weeks before they hatched; at a mean temperature of 17°C. the larval stage lasted 20, and the pupal stage 5 days. *A. bifurcatus* larvae remained two to three months under winter conditions. Adult forms of *A. elutus*, *A. superpictus* and *A. bifurcatus*, were found during January, February and March, when it was certain that there was little or no breeding.

Hibernation in the true sense of the word does not occur in Palestine, because the temperature is not uniformly below the level at which activity ceases. Larvae were noted to cease activity at temperatures below 12°C. and become active again as soon as the temperature rose to 14°C. or over. At low temperatures the larvae lie supine

Hibernating Adult Anopheles.

Place.	Numbers found in		Species found.			Date.
	living and sleeping rooms.	stables, cellars and storehouses.	<i>A. elutus</i> .	<i>A. superpictus</i> and <i>A. sergenti</i>	Other species.	
<i>Coastal Plain</i> ..					<i>multicolor</i>	
Zichron ..	144	217	342	0	19	ii.1923
Shuni ..	52	58	93	5	12	"
Tel Zur ..	14	20	35	0	0	"
Hedera ..	4	64	64	4	0	"
Gan Shmuel ..	2	19	21	0	0	"
Hefzi Bah ..	55	63	118	0	0	"
Karkur ..	1	22	33	0	0	"
<i>Upper Galilee</i> ..						
Rosh Pina ..	0	0	0	0	0	"
Mahnaim ..	6	0	6	0	0	iii.1923
Ayelet ..	0	12	0	12	0	"
Mishmar ..	38	40	76	2	0	"
Yessod ..	57	35	90	2	0	"
<i>Lower Galilee</i> ..						
Kineret ..	0	128	32	96	0	i-iii.1923
Degania ..	12	36	32	16	0	"
Betania ..	0	27	19	8	0	"
Menahemia ..	0	12	5	7	0	ii-iii.1923
Yahniel ..	3	125	6	122	0	"
Bet Gan ..	0	8	0	8	0	"
Mescha ..	0	0	0	0	0	"
<i>Valley of Jezeeel</i> ..						
Nehalal ..	1 (in tents)	4	12	8	0	i-ii.1923
Merhavia ..	22	264	250	36	0	"
Tel Adas ..	3	39	33	9	0	"
Balfouria ..	0	0	0	0	0	"
Ein Harod ..	0	29	20	9	0	"
<i>Judea</i> ..						
Ein Ganim ..	0	6	6	0	0	iii.1923
Mahneh Yehuda ..	0	0	0	0	0	"
Ekron ..	7	34	7	34	0	ii.1923
Hulda ..	5	0	0	5	0	"
Kfar Uria ..	0	8	5	3	0	"
Hartuf ..	3	1	1	0	3 <i>bifurcatus</i>	"
Rishon ..	0	0	0	0	0	"
Nahlat Yehuda ..	0	1	0	1	0	"

The table requires a few explanatory remarks.

- (1). The figures do not represent all, but the majority of the mosquitos.
- (2). *A. superpictus* and *sergenti* were not differentiated by the malaria inspectors, those specimens which were sent to the laboratory were all *superpictus*.
- (3). It is noteworthy that in the Coastal Plain and in Upper Galilee (except Ayelet) *A. elutus* was practically the only species found; in the Yavniel district *A. superpictus* was the sole species; in the other areas both species were found.
- (4). Storehouses and stables were the favourite hiding places for wintering *Anopheles*.

at the bottom of the dish, entirely motionless. This is apparently one of the reasons why larvae disappear completely during the winter months. They evidently remain motionless at the bottom of the wadi or pool and only appear on the surface when the temperature of the water rises. This fact was observed in the field late in March and early in April, when no larvae were visible after careful search in the morning, but could be found readily in the afternoon when the temperature of the water had risen to 18°C. or over.

Adult mosquitos also show this intermittent activity depending on the temperature. At temperatures over 16°C. they fed without difficulty and at 17°C. they deposited eggs. The large number of adult mosquitos found with partly digested blood is clear proof that they feed also under natural conditions; while the eggs brought in with the algae indicate that laying also occurs. This intermittent activity accounts also for the sporadic cases of new infections that appear throughout the winter months.

By way of conclusion it may be said that malaria-transmitting *Anopheles* may pass the winter season in all stages, but that hibernation is only partial. For all practical purposes, however, there is a period of complete quiescence from the middle of December to the middle or end of March, when mosquito control may well be discontinued.

**AÊDES (STEGOMYIA) MASCARENSIS, MACGREGOR: A NEW
MOSQUITO FROM MAURITIUS.**

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This new species of *Aedes* (*Stegomyia*) was discovered while I was conducting a malaria and anti-Anopheline survey in Mauritius for the Colonial Office during 1922-1923.

Two species of *Aedes* (*Stegomyia*) have been previously known to exist in Mauritius, namely, *A. (S.) argenteus*, Poiret (*Stegomyia fasciata*, F.), and *A. (S.) albopictus*, Skuse.

The latter species is to be found in large numbers everywhere in the island. It breeds mainly in tree-holes; like other *Stegomyia*, it bites normally only during the daytime, and it may be readily recognised by its jet black and silvery white coloration in conjunction with the conspicuous white line which runs longitudinally along the middle of the thorax.

Aedes argenteus in Mauritius is only to be found in restricted localities at the coast, the reason for this being so far unexplained. It is common at Port Louis, and at some other coastal centres of population, but it is not generally common even in the coastal belt of the island. The species has not been found in Mauritius to occur above an altitude of 500 feet. *Aedes argenteus* may be recognised by its black and white coloration, in conjunction with the well-known lyre-shaped white lines on its thorax. It breeds in tree-holes, and in many collections of water around human dwellings, such as water-butts, flower-pots, drains, gutters, etc.

Soon after my arrival in Mauritius, while I was in the Botanical Gardens at Pamplemousses one morning, I noticed a small black and white mosquito buzzing around my legs. Its flight was rapid, and it seemed easily frightened; consequently it disappeared as soon as I attempted to capture it. I noticed, however, that the insect seemed to have a conspicuously white thorax.

Shortly afterwards, when my laboratory at Reduit had been opened, larvae (assumed to be all *Aedes albopictus* larvae) were collected from a tree-hole and were set aside to develop. On the emergence of the adults, among the numerous *Aedes albopictus* several mosquitos of a new species were observed to be present, and were recognised to be the same as the one I had seen in Pamplemousses. On examination it prove to be a strikingly ornamented insect, and one easily distinguished from the other two Mauritian *Stegomyia* in the adult stage.

The following is a description of the male and female of this species. I have called it *mascarensis*, for although it has not been found to occur on Rodrigues, there can be little doubt that the species must exist on Reunion (Bourbon), which is only 80 miles west of Mauritius, and which, unlike Rodrigues, is constantly visited by vessels of all kinds from Mauritius and Madagascar. Search for it has not yet been made on Reunion, but it has been proved not to occur on Rodrigues at present.

***Aedes mascarensis*, sp. n.**

♀. *Proboscis* black and shiny while the insect is alive; black and dull after death. *Palpi*: first two joints black, third joint clothed with silvery-white scales, dorsally. *Antennae* black, but with first joint (basal joint) encircled on the upper peripheral margin with silvery-white scales. *Head*: eyes black, with a small patch of silvery-white scales extending forwards from the occipital region in the line separating the eyes. Occiput ornamented with flat silvery-white scales and long black hairs bordering

the median orbito-occipital margin; the silvery-white scales arranged as a patch covering the median dorsal aspect of the occiput, and as two separate longitudinal bands on the lateral aspects. *Thorax*: the whole of the dorsal surface of the mesothorax clothed with flat spindle-shaped and sickle-shaped scales and long black hairs. The flat spindle-shaped scales are conspicuously concentrated on the anterior lateral section of the mesothorax in the form of two large roughly triangular patches on each side of the thorax. By the higher reflective power of these flat scales the patches are clearly visible under the microscope when the insect is slightly turned on one side. A line of the long black hairs extends longitudinally on each side of the middle line as far as the scutellum. *Scutellum* decorated, and completely covered with flat silvery-white scales, and long black hairs which fringe the free margin. *Pleurae* decorated with numerous patches of flat silvery-white scales. *Abdomen* black, with basal bands of yellowish-white scales on segments 1-6. Segment 7 unbanded. A fan-shaped patch of flat silvery-white scales on the ventral aspects of all the visible segments. Venter with broad bands of yellowish-white and silvery-white scales intermixed. *Legs*: coxae and femora yellowish on the ventral aspects; tibiae black; tarsi black, some carrying white bands. Fore legs: 1st and 2nd tarsal joints with a patch of silvery-white scales at their bases; 3rd tarsal joint all black; 4th and 5th tarsal joints brownish-black. Middle legs: 1st and 2nd tarsal joints with a patch of silvery-white scales at their bases; remaining joints all black. Hind legs: 1st, 2nd and 3rd joints with narrow basal bands of silvery-white scales; 4th tarsal joint with a broad band of similar scales; 5th tarsal joint all white. *Wings* uniformly black-scaled.

♂ *Proboscis* black, long and slender. *Palpi* about as long as the proboscis. Apical portion of the 1st joint with a dorsal patch of silvery-white scales; 2nd joint with a broad band of similar scales at its middle; 3rd and 4th (terminal) joints with a basal patch of white scales on the ventral sides. *Abdomen*: segments 6 and 7 without the basal bands of yellowish-white scales. Otherwise the male is similar to the female.

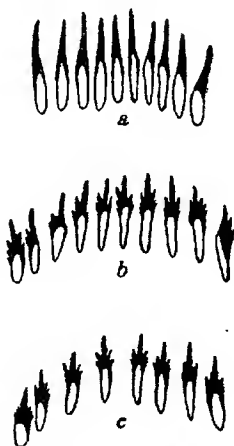


Fig. 1. Abdominal combs of Mauritian species of *Stegomyia*: (a) *Aedes (Stegomyia) albopictus*; (b) *A. (S.) mascarensis*; (c) *A. (S.) argenteus*.

Aedes mascarensis is to be found breeding in tree-holes all over Mauritius, but it is not as common a species as *Aedes albopictus*, with whose larvae the larvae of *A. mascarensis* are often found associated. With the unaided eye it is almost

impossible to distinguish the larvae of the two species, although the larvae of *A. mascarensis* have often not quite so many stellate spine hairs on the thorax and abdomen. Under the microscope, however, the two species may be instantly distinguished from each other by the morphology of the comb, which occurs on the lateral aspects of the 8th abdominal segment (fig. 1, a, b).

It will be noticed, under the low powers of the microscope, that the comb-teeth of *A. albopictus* are simple, whereas the comb-teeth of *A. mascarensis* are denticulated.

In this respect they are very much like the larvae of *A. argenteus*, but during my investigations in Mauritius *A. mascarensis* and *A. argenteus* were never found breeding in association. It is conceivable, nevertheless, that, since both these species may breed in tree-holes, they may at times occur in the same tree-hole, and it is therefore necessary to point out the most conspicuous specific larval difference between them.

Unfortunately the larvae of *A. mascarensis* and *A. argenteus* are so much alike that it is a matter of difficulty to find any character which will make the identification easy, and the only fairly reliable differences which I have been able to observe are slight differences in the structure of the comb, the average number of teeth in the comb, and the average number of teeth in the pecten of each species. These characters are given in the following dichotomous tables.

Genus *Aedes*, Mg. (Edwards).

"This genus, as a whole, is characterised as follows:—Proboscis of uniform thickness throughout. Palpi of the female less than one-quarter as long as the proboscis. Antennae distinctly plumose in the male, with the last two joints elongate; with moderately long verticils in the female, all the flagellar joints being about equal in length. Eyes distinctly separated. A continuous row of orbital bristles. Pronotal lobes widely separated. Pro-epimeral bristles about 4-6, in a posterior row overlapping the spiracle. Spiracular bristles absent. Post-spiracular, pre-alar, sternopleural and upper mesepimeral bristles all present and generally numerous. Postnotum without setae. Eighth segment of the female abdomen retractile, a wide membrane between it and the seventh. Side-pieces of the male hypopygium with a lacuna of chitinisation extending the whole length of the inner side; claspers articulating in a horizontal plane. Tenth segment with tergites feebly developed; sternites simple, without teeth or spines. Hind tibiae with the usual row of fine microscopic hairs just before the tip on the inner side, and also with a row of 7-10 longer hairs parallel with the first row and slightly more distally placed. First hind tarsal joint shorter than the tibia. Pulvilli absent. Front and middle claws of the female nearly always toothed. Cell R_2 (upper forked cell) seldom much longer than its stem. Vein A_1 (sixth longitudinal) terminating distinctly beyond the level of the base of R_2 (second vein). Distinct microtrichia on the wing-membrane."

Subgenus *Stegomyia*, Theo.

"Proboscis moderately slender, but stouter than in *Ochlerotatus*, scarcely as long as the rather short front femora. Palpi short in the female, normally longer than the proboscis in the male, the last two joints slender, upturned, with very few hairs. Vertex with broad flat scales, few or no narrow ones on the nape. Thorax usually with conspicuous and well-defined ornamentation. Lower mesepimeral bristles absent. Male hypopygium usually without claspettes, unless these are represented by hairy basal lobes; no apical lobes; clasper with distinct terminal spine. Aedeagus divided into two more or less brush-like halves. Eighth segment of the female abdomen rather large, but distinctly retractile, the sternite not very prominent in repose; cerci rather short. Front and middle claws of the female either toothed or not."

Key to Adults of Mauritian Species of Stegomyia.

1. Dorsal surface of the thorax covered with silvery-white scales ... *mascarensis*
2. Dorsal aspect of the thorax ornamented with a silvery-white stripe running longitudinally in the median line ... *albopictus*
3. Dorsal aspect of the thorax ornamented with two parallel lines enclosed by two lines bordering the dorso-lateral aspects of the thorax, and forming a lyre-shaped device ... *argenteus*

Larvae of the Genus *Aedes*, Mg. (Edwards).

"Mouth-parts not specially modified for predaceous habits, but the inner hairs of the mouth-brushes are generally more or less serrate. Antennal tuft generally at or before the middle. Abdomen without chitinous plates except for the anal saddle, and sometimes small plates at the bases of the thoracic hairs. Eighth segment with a lateral comb or patch of scales. Siphon unmodified, short and stout, at most four times as long as its breadth at the base, provided with a well-developed pecten and a single pair of ventral hair-tufts, situated about or beyond the middle; only very exceptionally with accessory dorsal hairs or hair-tufts."

Larvae of the Subgenus *Stegomyia*, Theo.

"Antennae short, with a single hair and without spicules on the shaft. Frontal hairs single. Abdomen with or without numerous stellate tufts on the dorsal surface; the eighth segment with a definite comb of teeth set in a single row. Siphon not much more than twice as long as broad; hair-tuft well developed, and situated about the middle."

Key to the Larvae of the Mauritian Species of Stegomyia.

1. Larvae with numerous stellate spine hairs on the abdomen and thorax; teeth of the comb simple, when examined under comparatively low microscopical powers ($\frac{2}{3}$ in. objective) ... *albopictus* (fig. 1)
2. Larvae with comparatively few stellate spine hairs on the thorax and abdomen; teeth of the comb denticulated when examined under comparatively low microscopical powers ... 3
3. Average number of comb-teeth 8; average number of pecten teeth 15-20; pecten hair-tuft usually situated slightly beyond the last tooth of the pecten; the last tooth often a little removed distally from the preceding tooth; inferior denticles mainly less than half the length of the superior denticles ... *argenteus* (fig. 3)
4. Average number of comb-teeth 10; average number of pecten teeth 8-12; pecten hair-tuft usually situated at about the same level as the last tooth of the pecten; inferior denticles mainly half or more than half the length of the superior denticles ... *mascarensis* (fig. 2)

It must be confessed that the only differences in the specific characters of the larvae of *Aedes mascarensis* and *A. argenteus* are so slight, and moreover sufficiently variable, as to cause at first some difficulty in distinguishing the species. This is remarkable when the adults are so easily recognised. Prolonged comparison of the larvae has failed to reveal any more conspicuous specific character, but I have found, with experience, that identification by means of the characters of the comb and pecten is fairly certain.

A NOTE ON THE FERTILISATION OF ANOPHELES.

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Fertilisation of the indigenous species of *Anopheles* in England, as far as I know, has not been brought about while the insects were in captivity. Several investigators have attempted to induce fertilisation in order to maintain strains for laboratory experimental purposes, but without success. While in charge of the War Office Entomological Laboratories at Sandwich, Kent, during 1919-1920, I attempted to induce fertilisation in captive *Anopheles maculipennis* and *A. bifurcatus*, but failed to do so even under the very favourable environment under which the insects were kept—such as large scientifically constructed insect-cages, an electrically heated insect-house, electrically controlled atmospheric humidity, an animal and human blood supply, etc.

The belief is that fertilisation of *Anopheles* takes place by a nuptial flight; males and females uniting while in flight at a considerable altitude above the earth. In fact this phenomenon has been described as witnessed by several people.

Consequently, while undertaking investigations on the bionomics of the Anophelines in Mauritius recently, I was surprised to find that it was a matter of no difficulty to induce the fertilisation in the laboratory of the four species present in the island, namely, *A. mauritianus*, *A. maculipalpis*, *A. costalis*, and *A. funestus*. It was only necessary to allow emerging adults from collected pupae to associate in the same cage, providing the males with a diet of honey-water, flowers, or moistened dried fruit, and the females with blood meals. Invariably fertilisation would ensue from 12 to 24 hours after the emergence of the mosquitos, and with further blood meals all the females would develop and lay normal batches of viable eggs from which active and quite normal larvae would hatch.

It was found by observation that mating only took place at sundown or in the early hours of the morning, but in one instance by keeping the males isolated from the females and then placing both sexes together in the same shaded cage at 12 noon, fertilisation followed. In fact at these times the activity was such that the *Anopheles* might well have been *Aedes argenteus*.

It seems strange that this should have been the rule among four different species of *Anopheles* in Mauritius, and that in the more northern latitudes of Britain a nuptial flight at high altitudes should be necessary for fertilisation. It is possible that some slight but important factor has been missed which may account for the failure to induce fertilisation in the laboratory of our British Anopheline species.
